New York Teachers' Monographs

Nature Study and Elementary Science

EDITED BY

SIDNEY MARSDEN FUERST

Oswald Schlockow James A. O'Donnell

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Vol. IV. MARCH, 1902 No. 1

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EDITED BY

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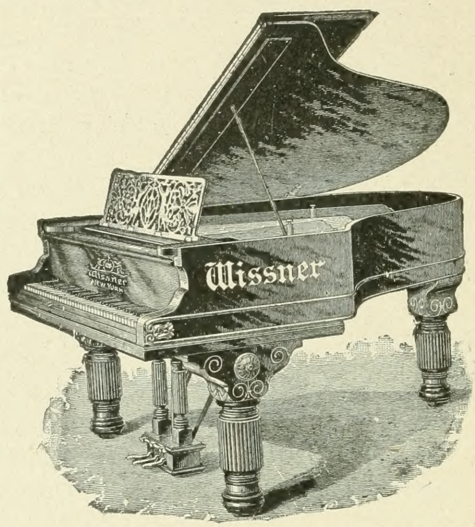

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New York Teachers' Monographs.

NATURE STUDY and ELEMENTARY SCIENCE.

MARCH, 1902.

Criteria of Nature Study.

By C. F. Hodge, Professor of Physiology and Neurology, Clark University.

WHAT shall determine the topics that we introduce into the nature study course ? Many practical answers to this question have been given in the text-books and outlines for courses, and we see from these that each point of view necessarily carries its own criteria. If we adopt the æsthetic standpoint, we will make beauty the criterion in selecting our subject matter. If we take the so-called scientific point of view we must select those things, type forms, etc., that lend themselves to systematic arrangement and presentation. For the past five or six years I have made it a point to collect texts and outlines from all available sources, and, much to my regret, they have borne in upon me the conviction that the generally accepted standpoints are inadequate both as regards the subject matter to which they would direct attention and in regard to the fundamental educational needs of the child. I have discussed these matters elsewhere (*) somewhat at length and in the brief space of this article I wish to develop more fully the fundamental results of my own studies.

A great advance has been marked in recent years, for which we are largely indebted to Professor Bailey, in breaking from the hard and fast lines of systematization and in keeping a course of nature study plastic, informal, closely in touch with the natural and spontaneous interests of both children and teacher. The interests of the teacher are likely to dominate the course; for, in this field, at least, we should hardly hope for the best results, if he is required to give instruction about subjects in which he has no interest. The field of nature is so boundless that any teacher, not wholly artificialized, will find wholesome interests; and while as parents we should be willing that he make these a strong feature of the course, we would still feel that there should be a reasonable degree of symmetry and completeness in the course as a whole. That is, we should hardly be satisfied to have the course in nature study devoted to minerals, or to birds, or trees, or any other one phase of the child's natural environment. The children in any class will naturally have different tastes and inclinations, and the work should

* Foundations of Nature Study, The Pedagogical Seminary, Vol. vi., pp. 536–553, and Vol. 99, pp. 95–110 and 208–228.

be planned to open up avenues of interest in various directions which may appeal to all.

There are two other dangers in a plastic nature study, which, unless we guard against them, are likely to wreck this most hopeful movement. The teacher is taking long summer courses looking toward a higher, possibly medical, degree in some college or university. He becomes enthusiastic in his studies and, without realizing the absurdity, is soon introducing lessons in comparative osteology, which belong in the university course, into his primary and grammar grades. There is no doubt about the "enthusiasm" of the class, and very soon a half-baked medical student can have the boys taking to the woods to kill and boil animals for their lessons on bones. The other danger is the opposite of this. The teacher is engrossed with other things and has cultivated no wholesome nature interests. He does not see the flowers, he never hears a bird song, is never tempted to stop a moment and watch the insects in his path. Time for the lesson comes and finds him unprepared. He seizes upon the first thing at hand, a broom splint, a sliver of pine, a knot-hole, and fills in the time with a haphazard lesson, interest in which on his part is momentary and fictitious, on the pupils *nil*. Of course there are all degrees and shades of variation in the evils of which the above are typical. That these dangers are not imaginary is proved by the fact that the committee of a teachers' reading circle were recently influenced against taking up the subject by the argument that nature study had proved a failure in New York and California.

Still, with every pulse and throb of our educational life, with every new application of evolutionary thought to our problem, with every added truth that child study and psychology brings, we feel deeper and more keenly the need of a true and vital tuition of Nature, the Old Nurse of everything that lives. In seeking a more adequate standpoint and deeper criteria than any I have been able to find, my mind has turned with the persistence of a magnet to its pole toward the long struggle of the race, "the ascent of man," toward higher and more perfect "response to the order of nature."

The argument that I draw therefrom may appeal more forcibly to those who hold that the child, in his individual developments, a he does physically, psychically repeats the story of the race. Personally I share to only a slight degree in this opinion; for I find the brain, the organ specially developed for education, far too plastic, far too easily educated this way or that, far too spontaneous and original, to bear up any such hard and fast hereditarian dogma. It is at best with only the vanishings of instincts that the child is born. He comes with absolutely no knowledge of the world as his ances

tors knew it in order that he may learn the world as he finds it. At any rate, by every inch we yield to heredity and the *Parcæ*, we shorten the leading strings of *Fortuna*. Even with animal instincts, if we do not give them the environment in which to act, they speedily fade away. Studies on the brain have demonstrated that if a sense is lost in infancy, cells in the corresponding part atrophy or lie dormant. What is so clearly seen in the purely sensory areas probably holds true for the higher centers of association and psychic life. If this is true, when we fail to give the child his natural environment during the years of growth and plasticity, the brain will not grow by hereditary impulse, and we shall face dormancy and atrophy for life. The argument thus gains in force in proportion as we disallow the hereditarian dogma. The overwhelming fact is that life is cast into the midst of nature as the great matrix of education. This should truly cradle and swaddle the child, especially in his early fundamental and elementary education. A system of elementary education that gives to the child in place of nature an environment of symbolism, prematurely, I feel deeply is a system that leaves out truly elementary education itself.

According to the luminous definition of Professor Brooks, which is in essence the same as that of Aristotle, "life is response to the order of nature." A lowly organism responds to but a little of the order of nature. The higher the organism the more complete and perfect is the response to the infinitely varied and complex stimuli with which nature plays upon the sentient being. A shallow philosophy of life would assume that modern man had attained to a full response. How often do we hear from the red school-house man: "The education that was good enough for me is good enough for my boy." But science, which is but higher nature study, disproves and flouts this idea. Far truer is the philosophy: As the amœba is to man, so is man as he now is to the man that is to be. This philosophy is the torch that must light our way to the adequate criteria for nature study.

In almost the same breath Dr. Brooks says: "Life is education, and conversely, education is life;" or again: "Life is knowledge in use." Since response presupposes knowledge of the order of nature, these apparently different statements all melt together into the same lump of pure educational gold. Carlyle touches the same basal truth when he says: "Knowledge? The knowledge that will hold good in working, cleave thou to that; for Nature herself accredits that, says yea to that. Properly thou hast no other knowledge but what thou hast got by working; the rest is yet all a hypothesis of knowledge; a thing to be argued of in schools, a thing floating in

the clouds, in endless logic-vortices, till we try it and fix it. 'Doubt, of whatever kind, can be ended by action alone.'" Hence the prime criterion which we must apply to every lesson, the touchstone with which we must test whether it is glittering dross or gold, is the relation of the lesson to the whole-souled, spontaneous activity of the child.

But in the buzz and glitter, and amid the artificiality of our modern life, we must distinguish between activity that is true to nature and that which is essentially false to nature. In this, again, I know of no safer guide than the story of the race as mankind has struggled up into higher and still more perfect life by higher and more perfect responses to the order of nature.

The nature study of the race has been long. Even history is long, but nature study was old before history began, and modern science is but the breakers along the shore of the ocean of educational progress. How little of the latter is really "knowledge in use"! And for nature study it is a profound mistake to attempt any of our science that is not "knowledge in use."

The progress of the race is strewn with rubbish, with mistakes, with experiments that did not stand the test of use, with moulted shells and cast-off armors that served their time and have been left behind. In the development of any animal we find all sorts of short cuts, abbreviations and accelerations by which the embryo has dodged these pitfalls and obstacles, and, while living through the essential stages, has come out in the form best fitted for the pursuit of its life work. I cannot but think that educational theories which have been grouped about the "historic occupations" have failed to grasp the significance of this fact. There is a real danger of arrest in forcing the child to lug up and try on the cast-off trumpery of the past. Hence, we must further distinguish between the essential and fundamental and the merely trivial and temporary activities associated with human progress. For example, if I wished to make a sharpshooter, I would not keep a boy throwing stones for a year, then give him a year with bows and arrows, and so on. True, he might get some exercise and coordination of muscles and brain out of it, but we can find modern games and exercises better adapted to physical development. I am aware that there are wide differences of opinion in this field; but at the proper time I should give him a modern rifle and send him daily to the target field with other boys to shoot against; and it would not matter to me whether he had ever cast a spear or drawn a bow. The same is true with spinning and weaving, building fire with flint and steel or bamboo, working in wood or metal by antiquated methods. Let the relics of all such old trumpery stay in the museums where they belong. They no longer have relation to life.

When first strongly impressed by the doctrine that the child

repeats the history of the race, I thought that of all things we must bring hunting and fishing into a rational course of nature study. I remembered my own boundless delights in these primitive occupations, surely "reverberations" from a savage past. I had not gone far into details, however, before I realized that those were the dear old days of "hookey." Lessons in hunting and fishing would have spoiled them forever. Then, too, there is no relation in hunting and fishing to the development of civilization. Tribes that have advanced no higher than this have remained savages, even as the brutes live by hunting and fishing.

There are other limitations to the criterion of activity that must be noted. Since primitive times, occupations have become differentiated and specialized into guilds and trades. These have long been recognized as matters of adult life which are prepared for by special education that is begun after the nature study period is passed. Hence, in order to select subject matter for the child, we must again seek elements that lie deeper than these. We are thus obliged to safeguard manual training on every side to keep it from trade instruction, and even in so fundamental an occupation as agriculture we must leave the special and technical for later years.

It may appear to some like going a long ways back, but Moses seems to be about the only educational writer who has stated the problem in the large. According to him, the purpose of God in creating man in His own image was that he subdue the earth, hold dominion over every living thing, make the world a paradise. This gives us in a word the fundamental currents of human nature study. Looked at from the standpoint of evolution, we have the long struggle of savage man to subdue.

We next see the beginning of a rational dominion over nature in the domestication of animals, of nomadic peoples. This work is only well begun. Finally, with the cultivation of plants, comes the great uplift into civilization. In this we have the beginning of stable landhold and of home; and with love of home has come love of country. The foundations are laid for populous communities and for differentiation of trade, commerce, art, literature, science, philosophy and even religion; for were not Osiris, Demeter and Saturn deified, because they led their people out of barbarism by teaching them the arts of the soil.

I would thus make these fundamental currents of human life, as for the race, so for the child, the basal criteria for nature study.

"The consummate product of a world of evolution is the character that creates happiness, that is replete with dynamic possibilities of fresh life and activity in directions forever new. Such a character is the reflected image of God, and in it are contained the promise and the potency of life everlasting."—John Fiske.

Nature Study in the First Three Years.

By Amy Kahn, Author "Hours With Nature," Instructor, New York City.

Grade: First Year, First Half.

Suggestive List—Fall Term.

SEPTEMBER: The cat, the dog; the golden-rod, the apple; growth from the seed.

October: The cow, the robin, the squirrel; leaves (change in coloring of and the falling of); familiar edible fruits.

November: The horse, the turkey, vegetables (those brought into class), attention drawn to general Thanksgiving vegetables and fruits, the pumpkin, corn, plums, grapes, nuts.

December: The hen, trees, evergreens.

January: Winter birds, the crow, the chickadee, germination should be begun, class-room illustration of germination, general talks on the subject previously taught.

Spring Term (refer to fall term)—A few additions.

February: The cat, the dog; germination, leading to talks on the awakening of spring.

March: The cow, the robin, seeds, sap, pussy-willow, blustering March winds.

April: The horse, the chicken, spring talks, Easter, "April showers bring May flowers."

May: The hen, the canary, the morning-glory, the grass, Arbor day, planting of trees, the buttercup.

June: General talk on subjects previously taught, the bee (a general talk), the daisy, the dandelion.

It is wise while teaching about an animal to have an outlined, tabulated form. The description of the animal would be a good beginning. If practicable, the animal may be brought into the class; if the animal chosen can not be obtained, a good picture, or perhaps a stuffed specimen, may be secured. The description would direct attention to the general appearance, to the construction of the body and to the position of the various parts. The characteristics may deal with the distinguishing qualities.

Habits: Habits that are natural, those that are acquired.

Actions: General actions (as to what the animal can do), actions peculiar at certain times. How the animal acts when well treated, when properly cared for. How different the actions are when the animal is ill-treated, is neglected.

Interesting facts: Those can be culled from the reading the teacher has done to prepare herself to teach her subject. Sometimes children can give some from stories told or read to them.

Anecdotes: "In The Child's World," E. Poulsson; "The Story Hour," S. E. Wiltse; "Hours with Nature," first and second books; fables, Æsop.

Songs: Hubbard's song collection; Kindergarten Chimes, Walker and Jenks's song book, Howliston's song book.

Games: Dramatization of some selected poems or songs.

THE HORSE.

Arranged according to the suggested plan.

Description: Body: covering of short hair; shape of head: elongated; nose: bare of hair; lips: with lips grasps its food; eyes (pupil oval-shaped): can see at the front, at the side, in the dim twilight; mouth: speak of bit; tail: long, protection to brush flies away; mane: mark of beauty; legs: long, almost straight; each foot, only one toe; hoofs: one on each foot; horseshoes: horseshoe is a protection for the hoof.

Characteristics: Patience, strength, affection, playfulness.

Habits (natural): Kind to its young, obedient, docile and gentle; acquired: taught to perform, to dance, to race.

Actions: Runs, trots, gallops, walks, canters, neighs, whinnies, snorts. Neighs, when asking a question; whinnies, when in need of food; snorts, when it is in fear.

Interesting facts: Horses named according to the work they do: carriage horses, race horses, circus horses, cart horses.

Uses can be mentioned. Every child will be interested to hear that the skin is made into leather; from the hoofs glue is made; draws wagons, carts, ploughs for the farmer.

Hair of the horse, thick in winter; it sheds its hair in the summer.

Bill of fare: Oats, hay, grass, water. Good art: Landseer; Rosa Bonheur.

Anecdotes: "A Wise Old Horse," in "In the Child's World," E. Poulsson; "What the Horse Does," in "Cats and Dogs," "Black Beauty," Anna Sewell; "A Little Talk on Ponies," "The Horse and His Rider," Æsop; "The Wolf and the Horse," Æsop. Songs: "The Blacksmith." Games: "The Blacksmith." Dramatization of a song, a rhyme, a poem, or perhaps a story.

A BIRD LESSON—THE ROBIN.

Description: Covering, feathers; body, reddish brown; color of under parts; head black, white marks above eyes, wings, breast deep reddish orange, bill slender, delicate.

Habits: Noisy, full of life in sunny weather, hardy, clean, (takes many baths), low spirited upon dull days, returns to same nest year after year, migratory, social.

Actions: Runs upon the ground, stands erect, perches, hops.

Uses: Gives pleasure by its songs, rids us of insects that are injurious.

Where found: In the woods, groves, glades, gardens.

Interesting facts: Eggs, four in number, bluish green. Speak to the children of the robin's sociability, how it wishes companionship, the noise the robin makes when in fear, the construction of the nest, Papa and Mamma Robin build the nest, how they love their young, patience of Mamma Robin with the little ones.

Memorize Longfellow's poem:

"The wind blows east,
The wind blows west,
The blue eggs in the robin's nest
Will soon have beak and wings and breast,
And flutter and fly away."

"Brother Robin," Lovejoy's "Nature in Verse," "Robins' Nests," in "Nature's Byways;" "The Robin," Lovejoy; "Nature in Verse," Lovejoy; "Little Robin Redbreast," in "Heart of Oak;" "Come Here, Little Robin," in "Nature in Verse," Lovejoy; "Robin, Robin, Redbreast," Walker & Jenks. Bird songs to be found in the "Kindergarten Chimes," Walker & Jenks's song book; Hubbard's collection, Eleanor Smith's songs, "Indian Story of Robin," Whittier; Pretty and interesting anecdotes telling of the birds, "Little Flower Folks," Beecher; "In the Child's World," Emilie Poulsson.

PLANTS.

A simple talk on growth from the seed is well illustrated by Emilie Poulsson in the "Finger Plays." Let the child learn "In My Little Garden Bed." Plant growth can readily be shown in class. Seeds may be planted in a sponge, on cotton floating in the water, between blotters and also in tumblers. Each stage is to be carefully observed and given proper attention.

A SPECIAL FLOWER—THE MORNING GLORY.

First: Let it be recognized and named; have various colored ones, white, red, etc.

Form: Like a trumpet.

Color: Deal with those present at lesson. Coloring of others spoken of.

Qualities: Beautiful, etc.

Uses: Pretty to look at; makes the world beautiful; in time the flower makes the fruit.

The fruit protects the little seeds. In the seeds are little baby plants waiting for their time to grow. Some time these baby plants will become mother plants and have little baby-seed children of their own.

A SPECIAL FRUIT—THE GRAPE.

Recognized and named (ordinary little black grapes shown).

Form: Round like a ball.

Color: Vary in color; red, green, blue, black.

Qualities: Soft, sweet, sour, juicy.

Uses: Food, juice used in preparation of medicines, juice made into wine; dried, used for cakes (raisins, currants).

A VEGETABLE—THE ONION.

First: Recognized, named.

Form: Ball-shape.

Qualities: Odor strong, hard, biting.

Uses: Food, sometimes eaten raw, sometimes cooked; taste of the onion is hot and burning.

A Spring Term—First Year, Second Half.

February: The chickadee, the hen, germination, the sun.

March: The goose, the swan, the robin, the earthworm, the birds, the wind.

April: The horse, the canary, the pussy-willow, the day, the night.

May: The cow, the apple, the lilac, the rain.

June: The sheep, the daisy, the bluebell.

Review of subjects previously taught.

Fall Term—First Year, Second Half.

September: The cat, the hen, the sun, the day; position of sun at various times of the day. Growth from seed; essential parts; parts of fruit.

October: The dog, the goose, the duck, fruits, nuts. Autumn, night (change in length of day and night).

November: The horse, the robin, the pigeon, wind, rain, Thanksgiving fruits, animals; preparation for winter.

December: The cow, the sparrow, the snow, the trees.

January: The horse, the crow, beauty of the snowflakes in form; evergreens. Review of subjects previously taught.

THE HEN.

Description: Covering, feathers; feet, two; toes strong, four; scratches with toes. Wings: Larger than those of the birds that

fly in the air or live in the trees. Body heavy, ears small and hidden; teeth.

Home: She puts her nest low on the ground, hides it in the grass; has been known to put it in the barn; sometimes the farmer makes a resting place for her.

Care of young: Loves her little ones, is an affectionate, patient mother, shelters them from all harm, will risk her own life for them.

Relations to man: Eggs, nourishing food for man; flesh, nourishing food for man; feathers, made into pillows, beds, dusters.

Talk of the hatching of the eggs: Mother hen sits on the nest day after day, night after night; keeps the eggs warm twenty-one long days. After twenty-one days there is a pecking at the shell, and out come the little chicks, covered with down. Then follows mother hen's protecting care of her young brood.

Literature: "The Little Red Hen," Ship Literature Reader; "Good Mother Hen," "Finger Plays," E. Poulsson; "The Hens," in "Nature's Byways;" "General Talk," in "In The Child's World," E. Poulsson; "The Hen's Nest," in "Stories for Children;" "Chicken's Ways, Friends in Feather and Fur," Johonnot; "Stories About Chickens," in "Feather and Fur," Johonnot; "Chicken Little," in "Graded Literature," No. II.; "The Woman and Her Hen," Æsop.

WHOLE PLANT AND ESSENTIAL PARTS.

Essential parts for development and for reproduction: General talk.

Root, stem, leaves, necessary for growth; root, undergound; stem, seeks the light, climbs above the ground; leaves appear on stem; plants do not live merely for the sake of blossoming, they have other work to do.

Bud, blossom, flower, fruit.

The fruit of the plant is a little secret box. The flowers die. The secret boxes remain on the plant. In the secret boxes little seeds are snugly packed away and kept warm. At some future time these seeds are planted. They grow and become mother plants. Some day they have little seed-baby children. Their friends are Mother Earth, Mr. Sun and Mr. Rain. Day by day they grow, and this keeps going on and on.

PARTS OF FRUITS.

The fruit of the plant is the ovary grown ripe. All of the plants have a fruit. The teacher should draw attention to the different types of fruit:

Apples, the fruit of the apple tree; peaches, the fruit of the

peach tree; acorns, the fruit of the oak tree; berries, the fruit of the rose bush.

The stone fruits should be observed. The children should look for the stone in the peach, the cherry or the plum.

The dry fruits, the nuts, the grains; the fleshy fruits, the apple, the pear.

Here the teacher must use her own discretion and know just how far she should go.

NATURAL PHENOMENA.

The sun, day, night, wind, rain, snow.

THE SUN.

How to tell the presence of the sun. What the sun gives us. How the sun helps the trees, the flowers and the plants. How the sun influences people's thoughts. How it helps to dry the clothes.

Songs: "Good Morning, Merry Sunshine," "If I were a Sunbeam," Lucy Larcom; "Sunshine," Lovejoy's "Nature in Verse."

THE DAY—THE NIGHT.

Rotation of earth cause of day and night. While the earth is rotating one half is turned toward the sun, the other half is away from the sun. The side turned toward the sun has day; the side turned from the sun has night. At night all things go to sleep; the birds and the flowers go to sleep, some animals go to sleep, we go to sleep. We awaken, when our part of the earth is turned toward the sun, and with awakening light we greet the new-born day.

THE WIND.

What is the wind? (Air in motion, can easily be explained.) Have you ever felt it blow on your cheeks? What kind of a sound does it make when it blows? What does it do? Can you see it?

Various winds: The north, the east, the south, the west. Effects of various winds, Memorize "What the Winds Bring," Stedman. Favorite memory gem:

> "Whichever way the wind doth blow,
> Some hearts are glad to have it so;
> Then blow it east, or blow it west,
> The wind that blows is surely best."

"Four Winds," Hiawatha; "How the Winds Blow," "Nature in Verse," Lovejoy; Anecdote, "The Sleeping Apple," in "In The Child's World," E. Poulsson; "The Wind," Robert Louis Stevenson; Fables, "The North Wind and the Sun," Æsop; "Sweet and Low," Tennyson; "Little Talks on Gentle Winds—Breezes," "Jack Frost,"

"The Wind" (sower of the seeds); "How West Wind Helped Dandelion," E. Poulsson; "Zephyr and his Brothers," "The Bag of Winds," "Nature Study in Elementary Schools," Mrs. L. L. Wilson; Reader (by the same author), myths, stories, poems.

THE RAIN.

Appearance of the sky, presence of black clouds. When the rain falls, how does it fall? Benefits of rain, how some of it soaks into the ground, how the roots of the plants drink it, how it runs down the hills, makes little streams called brooks and rivers.

Literature: "The Rain," R. L. Stevenson; "Who Likes the Rain?" Lovejoy's "Nature in Verse;" "Little Raindrops," Lovejoy's "Nature in Verse;" "The Rain Coach," Eleanor Smith's Songs for Children; "Story of the Rainbow," Hiawatha; "A Drop of Water," Hans Christian Andersen; "April Showers," Lovejoy's "Nature in Verse."

THE SNOW.

The color of the sky, the color of the snow, where the snow comes from, how did it get there? Who sometimes changes raindrops into snow? How does he use his icy hand? Effect of his icy hand touching the drop of water. Use of snow, drawing of a snowflake, snowflake always has six parts, beauty of the snowflake, fun in the snow, sleighrides.

"A Story for Willie Winkle," S. Wiltse; "The Snowflakes," Andersen; "The Snow Queen," Andersen.

Second Year—First Half.

September: The sheep, the ant, water, rain, golden-rod, oats.

October: The pig, the bee, the sparrow, the oak, the autumn, wheat.

November: Preparation of animals for winter, feathers and furs, squirrel, nuts; the sleep of flowers; color of, beauty of, clouds; appearance of frost; maple tree, the wasp, corn.

December: Wild geranium, grasshopper, evergreen.

January: The fly, germination in the classroom. General talk on subjects previously taught.

February: The sheep, the swallow, water, rain, the ant; germination continued; illustration by the pea and the bean germinated in the presence of the children.

March: The pig, the winter wren, the bee, sprouting observed, horse-chestnut, snow, ice, barley.

April: The rabbit, the bluebird, hepatica, sap, opened buds, parts of plant, uses of parts, rainbow, change in weather, April showers, the wasp.

May: Jack-in-the-Pulpit, elm, beech, poplar, the grasshopper.
June: The fly; general talks on subjects previously taught.

ANIMAL LESSON FOR THIS GRADE.

Observe covering, parts of body, kinds of food, adaptation to mode of life, use to man.

THE SHEEP.

Covering: Wool. Parts of body: Head small, mouth, absence of upper front teeth, moves jaws from side to side; legs, thin and short; feet, walks on toes, divided hoof covered with short wool; face hairy, wool short about the face, nose bare.

Kinds of food: Grass, hay, water, vegetable food, chews its cud.

Adaptation to mode of life: Its covering is such as to protect it from cold, the wool does not allow the heat of the body to come out.

Uses to man: Wool, clothing; flesh (food), mutton, lamb, skin, leather.

A little talk on shearing time may be introduced.

General talks on nests: Materials for construction, how constructed, where placed, purpose, uses.

Bird trades ("Nature in Verse," Lovejoy): From the child's observation the teacher will be able to gain the facts where birds build their nests (trees, under roofs, hedges, amongst grasses).

Materials for construction: Twigs, hair, feathers, moss, wool. The lining of the nest, soft material; how the material is gathered, how the birds carry the material in their beaks, go back and forth many times and never seem to tire.

Interesting facts: Birds do not always build new nests. Sometimes they find the old ones, repair them, sometimes use nests of other birds. Birds as a rule make a new nest for each little brood of young ones.

General talk on homes of animals: Dogs live around the house or in special homes called kennels, cats live around the house, birds live in nests, some animals live in shells, some animals dig holes in the ground, some animals dig holes in the trees, fish live in the water (fresh water or salt water), ants live in their ant hills, bees build cells.

General preparation for winter: Some insects make cocoons and bury themselves therein, some animals shed their coats and put on thick ones, store up food and hide the food till it is needed; the birds change their feathers, they migrate; the plants, leaves, begin to fade; the leaves change in color; the leaves fall to the ground.

INSECTS.

General remarks: Structure of body, three parts, head, thorax, abdomen, can be pointed out without the mention of scientific name; legs, six, three on each side; wings, two pairs; eyes, large; jaws, move from right to left; feelers.

A LITTLE TALK ON GRAINS.

Subject, wheat: Specimens of wheat distributed, single grain observed, taken from its little cradle (husk, chaff); familiar song, "Oats and Beans and Barley Grow;" add rye; wheat made into flour, process, crushing; farmers' work, first the sowing, then the reaping, then the threshing (threshing machine).

Art: "The Sower and the Reaper," "The Gleaners," Millet; "Cupid and Psyche."

Literature: "The Little Red Hen," "Cupid and Psyche," "Ruth Among the Gleaners."

NATURAL PHENOMENA.

Water, rain, snow, ice, fog, clouds, sky, rainbow.

THE SKY.

Appearance of the sky in the daytime. What is to be seen in the sky during the day? Appearance of sky at night. What is to be seen in the sky at night? What have we when the sun shines? When it does not shine? What covers sun at times and makes it dark here? Clouds, color of? Color of clouds indicates what?

THE RAINBOW.

Where do we see the rainbow? What makes the rainbow? Speak of the rainbow fairies (red, orange, yellow, green, blue and violet). The colors of the spectrum can be laid by each child. Speak of the prism rainbow. Let children find objects in nature having the colors of the prism rainbow.

The rainbow lesson can be concluded in the words of Longfellow:

> "Hiawatha saw the rainbow—
> In the eastern sky the rainbow.
> 'What is that, Nokomis?'
> And the good Nokomis answered:
> ''Tis the heaven of flowers you see there;
> All the wild flowers of the forest,
> All the lilies of the prairies,
> Where on earth they fade and perish,
> Blossom in that heaven above us."

"Rainbow Queen," "Cook's Myths," "Rainbow," Walker & Jenks's song book.

Fall Term—Second Year, Second Half.

September: The cat, the tiger, dependence of plants upon soil and moisture, rocks, stones.

October: The dog, the wolf, cultivation of plants, change of temperature, gravel.

November: The fox, the jackal; collection, comparison of leaves (venation, form).

December: The mouse, the rat, clay, effect of weather upon plants and animals.

January: The horse, the donkey, loam, action of water on streets and soil.

Spring Term—Second Year, Second Half.

February: The cat, the tiger, dependence of plants upon soil and moisture, rocks, stones.

March: The dog, the wolf (refer to fall term).

April: Refer to month of November in fall term.

May: Refer to month of December in fall term.

June: Refer to month of January in fall term.

Review of subjects previously taught.

Comparison of Animals and Distinguishing Parts.

THE CAT AND THE DOG.

Notice the cat's foot, dog's foot; difference, why difference? Notice the cat's ears, the dog's ears; notice the cat's tongue, the dog's tongue; notice the cat's covering, the dog's covering, the shape of head of each, difference; whiskers of each used for same purpose; cat good climber, dog good runner; both the cat and the dog like to eat flesh; both the cat and the dog tear their food with their sharp teeth; the cat hunts by sight, the acute scent of the dog aids him in telling him where to hunt; dogs bark, cats mew; cat's purr is a mark of satisfaction and expression of pleasure; dog's wagging of tail is a mark of pleasure; the cat and the dog become household pets. Fable: "The Cat and the Sick Birds," Æsop.

Dogs compared now with members of their own family: The wolf, the jackal, the fox; the gentleness of mistress pussy when properly treated; the cat and her wild kindred; members of her family, the tiger, the leopard, the lion.

Suggestive: Compare mouse with rat, horse with donkey, cow with sheep and goat.

"The Dog and His Shadow," Æsop. Dogs as life savers, their faithfulness to their masters, newspaper carriers, wild dogs; speak of the wild cats. In a limited space one cannot mention all the names of the many anecdotes, fables and poems to be found; St.

Bernard dogs save life on land; greyhounds, elegantly formed; Esquimaux dog, great aid in hunting, draws sleds; Newfoundland dog, not afraid of the water, is a life-saver; shepherd dog, his great use to the shepherd, helps to guard sheep, discovers the lost sheep.

Relation of Domestic Animals to Wild Animals.

GRADES: SECOND YEAR, SECOND HALF.

The Cat, The Tiger.

THE CAT.

Description: Covering, furs of different colors, smooth hair growing very closely together; head: round, ears large, hearing acute; eyes large, difference in daylight and at night-time; whiskers, feelers, measure if body can get into a hole or not; teeth sharp, tongue, forms it like a spoon, laps up milk; legs: paws, claws sharp, retractile cushions on feet let cat walk quietly.

Habits: Clean, bathes herself, her young, gentle to those kind to her.

Uses: Catches mice, frightens the rats away.

Actions: Walking, running, springing (on mice and birds for food, catching them with its front paws), climbing.

Interesting facts: Difference in colors of cats, cats dislike the water; the cat feeds her young with milk and takes care of them until they can care for themselves, sheds her hair in the spring, gets a thinner coat for the summer, purring when satisfied, mewing when in want, asking a question, social. The fur is often made into robes.

Anecdotes, etc.: "Familiar Animals and Their Wild Kindred." Other books given under reference list.

THE TIGER.

Description: Covering, beautiful fur; color, bright yellow, striped bands on its body, legs and tail; body beautifully shaped, feet padded, five toes on front feet, four on hind; teeth strong, tongue rough.

Habits: Hides until its prey is near then springs upon it, selects a home in places covered with long grass wherein it can hide; cruel, sometimes eats its little ones; good swimmer.

Uses: From its fur carriage rugs are made, rugs for rooms.

Home: In Asia, tiger hunts may be spoken of.

Anecdotes: "Familiar Animals and Their Wild Kindred."

Plants: Dependence of plants upon soil, sun, moisture, cultivation of plants, some plants need a dry soil, some a damp soil, some thrive in the sun, others in the shade, some on the mountains, some in the valley.

COLLECT AND COMPARE LEAVES.

Study beauty of form, color, texture. Familiar leaves should be taken: Apple, maple, oak, horse chestnut, pine, etc.

Form: Linear, grass; heart, lilac; hand-shaped, maple; round, geranium; oval, apple; needle, pine.

Color: Green; difference in summer, in autumn; red, brown, yellow, golden.

Texture: Glossy, smooth, light, rough, heavy, dull.

Venation could be shown by illustration, by observation; show veins of hand, veins in leaves, how veined? Use of leaves could be told: food for some animals, protect some buds, shade, give soil; make the earth look beautiful; cabbage, lettuce, spinach leaves are food.

THE SEASONS—SPRING.

Signs of spring. Why season so called? How about the birds, the insects, the grass? What about seeds, the buds, the flowers? Who are the helpers of the spring? Buds are swelling, sap is running, grass is peeping, flowers are awakening. Which are the early spring flowers? What have other people said about spring?

"Waiting to Grow," "Arbor Day Manual," Skinner; "Coming and Going," "Return of the Birds," Burroughs; "Spring Has Come," O. W. Holmes. Appropriate spring literature; in Lovejoy's "Nature in Verse" are the following: "If I were a Sunbeam," "The Voice of the Grass;" "The Tree," "Pussy-Willow," are in "In the Child's World; "The Sap Has Begun to Flow," Smith song; "The Robin," Celia Thaxter, Lovejoy; "Seven Times One," Jean Ingelow; "Hide and Seek," Frank Dempster Sherman; "Birds in Spring," Johonnot; "Baucis and Philemon," "Proserpine and Baucis," "Story of the Poplar," from Nature Study in Elementary Schools; Reader: Myths, stories, poems, Mrs. Wilson; "Spring," "Hours with Nature."

SUMMER.

Season follows spring; mental comparison; spring and summer; days (long); nights (short).

Summer months: June, month of roses; July, heat, days hot; August, cool nights.

"The Use of Flowers," Mary Howitt, in Lovejoy's "Nature in Verse;" "The Works of God," Lovejoy; "Summer Woods," Mary Howitt; "Chorus of the Flowers," Wheelock; "The Busy Bee," Isaac Watts.

AUTUMN.

Season follows summer; mental comparison; summer; autumn; length of nights (longer); weather cooler; appearance of

frost; fruit ripens; fruit gathered in harvest; corn gathered in harvest; falling of leaves; season also called fall. Months: September, October, November; birds flying to warmer countries.

Appropriate autumn selections: those in Lovejoy's "Nature in Verse," are "September," Helen Hunt Jackson; "Autumn Leaves," Cooper; "How the Leaves Come Down," Susan Coolidge; "November," Alice Cary. Howliston's song book; "Song of Harvest," Whittier; "The Anxious Leaf," Wiltse; "October," Helen Hunt Jackson; "The First Thanksgiving," "Story Hour," K. D. Wiggin; "The Turkey," Alice Cary; "The Birds' Thanksgiving," S. E. Wiltse; "For An Autumn Festival," Whittier; "Over the River and Through the Woods" (Lovejoy's "Nature in Verse").

Winter follows autumn; birds are where? Leaves of trees have fallen; plants' work finished; insects prepare for winter; some spin cocoons (caterpillars); some store food away (squirrels); some go to homes underground; animals get thicker coats to keep off the cold; days become cold; sun at its lowest in the sky makes the weather coldest; frost appears more often; north wind blows. Months: December, January, February.

Appropriate winter selections: "The First Snow," Lovejoy; "Who Comes Dancing Over the Snow?" D. M. Craik; "The Snowflakes," Hans Andersen; "Snowbound," Whittier; "The First Snowfall," James Russell Lowell; "The Snowflakes," Longfellow; "Where Do All the Daisies Go?" Howliston's song book.

EFFECT OF WEATHER UPON PLANTS AND ANIMALS.

In the coldest parts of the earth, where there is very little heat and very little light, the only plants we find are mosses and lichens.

Let us travel to that region where there is more heat, more sunshine and more rain; we find many plants: fruit trees, pear, peach, apple, bananas, lemons; flowers, roses, daisies, violets, geraniums, snowdrops; cotton, corn, wheat, tea; trees, maple, pine, oak, poplar, birch.

There is a region of the earth where there is the most heat and the most rain; here we find the greatest number of plants. Different *plants* belong to different *zones*.

EARTH STUDY.

Rocks, stones, gravel, sand, clay and loam; action of water on streets and soil. Specimens of these rocks worn away by the water should be brought into class and examined individually; children's observations to be the class work. Water in action wears the stones.

Formation of the pebble: A continual rubbing against other stones, caused by the action of the water. Rounded pebbles, gravel;

finest grains, sand; those black in color, loam; clay, plastic (water does not permeate it); clay earthenware, spoken of. Clay affords many interesting talks.

Third Year—First Half, Fall Term.

September: Flesh eaters, cardinal points, direction of winds.

October: Gnawers, sunrise, sunset.

November: Preparation for winter, cocoon, grass-eaters, farewell of birds.

December: Classification of birds, kindness to animals, weather record, length of days, evergreens.

January: Earth study, review of subjects previously taught.

Spring Term.

February: Flesh eaters, cardinal points, length and direction of shadows.

March: Gnawers, winds, migration, frog from tadpole.

April: Grass-eaters, sunrise, sunset, moth from caterpillar, beautiful moth from crawling caterpillar.

May: Classification of birds, weather record, kindness to animals.

June: Earth study, length of days, days longer, tree shadows, review of subjects previously taught.

Any natural history gives animals according to classification asked for in the course of study.

Animals that eat flesh, that gnaw, that eat grass.

Birds are treated as perchers, swimmers, birds of prey.

The main fact to be impressed upon the mind of the child is to show the structure of the animal for its life work.

Flesh-eaters have powerful paws with sharp nails, long, strong, pointed teeth to seize prey, strong, cutting teeth to eat flesh.

The gnawers have two long teeth on each jaw that rub against each other, gnawing that which comes between them. A backward and a forward movement of the jaws is always going on

Grass-eaters: Grass-eaters have flattened-out teeth which allow them to grind and crush the herbs and the grass they eat.

Ruminants have a peculiar way of chewing without seeming to eat, they ruminate—hence their name, ruminants.

Mention the peculiarities of the four stomachs.

How the food passes through one, two, three, four stomachs.

Flesh-eaters: Cat, lesson given above; tiger, lesson given above; lion, dog, wolf, fox, jackal, leopard, bear, hyena, jaguar, puma.

Gnawers: Rabbit, squirrel, lesson given below; dormouse, rat, mouse, woodchuck, prairie dog.

Grass-eaters: Horse, lesson given above; ass, zebra, deer.

Ruminants: Camel, lesson follows; cow, giraffe, oxen, sheep, lesson given above; moose, reindeer.

Birds that are perchers have on their feet three toes in front, one behind. Claws long, thin, sharp, strong; strong enough to allow the bird to perch where it sees fit.

Swimmers have webbed feet, short, strong; position of legs, way far back on the body, enabling them to swim readily.

The birds of prey have strong legs, sharp claws; the claws are an aid in catching prey; shape of claws, like a hook, so as to tear the food.

Waders have long thin legs; on account of the length of the legs are called stilt-walkers; toes are spread, so shaped as to make wading easy.

Runners: Long slender legs, strong too.

Climbers: Two toes before, two behind; able to cling to pole or to branch upon which they climb.

Birds of prey: Eagle, lesson given below; falcon, owl, lesson given, condor, hawk, vulture.

Perchers: Canary, sparrow, swallow.

Swimmers: Goose, duck, swan.

Climbers: Parrot, woodpecker, monkey, squirrel, lesson given.

Scratchers: Hen, lesson given, turkey, goose, lesson given.

Waders: Stork, snipe, crane.

THE CAMEL (ruminant).

Description: Body, covering hair; on back one or more humps; stomachs (number), how one holds water; head, small; eyes, long lashes, to protect it from the hot glare of the sun; legs, long; hoofs, cleft; nostrils, can be closed, preventing sand from entering; ears, small. Habits: Endurance of hunger great, endurance of thirst great, easily adapts itself to mode of life. Characteristics: Strong, patient, faithful, needs little attention, voice is a roar. Uses: Hair for shawls, brushes; beast of burden, milk.

A GNAWER—THE SQUIRREL.

Description: Body, covering fur; head, broad but small; eyes, large, dark; teeth, gnawing ones, always growing; paws (forepaws four toes); claws, curved; tail, long, bushy. Habits: Hides its store of food till ready for it; remembers, active, lively, leaps quickly, climbs rapidly; way of eating, sits on its haunches, holds food with forepaws. Uses: Skins for garments for children; tails made into boas. Speak of kinds: Common, flying, black, gray, red. Literature: "The Squirrel," Familiar Animals; "The Squirrel," Nature's Byways.

A BIRD OF PREY—THE EAGLE.

The eagle hunts for its food in the daytime. Every part of the eagle is so constructed as to help in its destructive ways. Beak: short, strong, hooked, bent at the tip; wings: large, strong, helping it to fly quickly; eyes: can see at great distances, sunlight causes no annoyance; feet: short, strong; toes: strong, four, beneath toes pads; claws: sharp at tip, sharp edges, large, strong; tail: long, strong feathers; habits: careful of young, keeps them well fed, keeps away from man, puts nest away from reach of man; food consists of flesh, lamb and rabbits are favorites, calves, kids.

Interesting facts: Kinds: golden eagle, harpy eagle, ring-tailed, sea eagle, bald-headed eagle. Bald-headed eagles will carry off young pigs; feathers used for ornamental purposes; the eagle is the national emblem of the United States, of France, of Austria, of Russia; it was worn on the standard of Roman legions years ago; it is the military standard of the German Empire.

A BIRD OF PREY—THE OWL.

The owl hunts for its food at night.

Description: Covering, feathers soft, flight noiseless, head large, eyes front of the head, can see in the dark, bill hooked, strong, claws hooked, sharp, aids in defence, beak aids in defence, ears hearing keen, can tell where its prey is, legs stout. Habits: Makes a nest in the hollow of trees, hoots, destroys injurious animals. Food: Small animals, birds, insects.

THE SWALLOW.

The swallow is a *percher*, dwell on peculiarities of perchers, draw attention to toes, wings, claws. Kinds: Chimney, sand martin, fairy martin, house martin, barn swallow, bank swallow, cliff swallow, the swift; swallows fly quickly, easily, migrate in the autumn, return in the spring, year after year return to same vicinity. Construction of nest: Mud, clay; kept together with straw, lined with feathers. Choice of place: Where winds will not disturb it; destroys insects that are injurious to us.

THE GOOSE.

Description, body, shape: Covering, feathers, oily; wings strong; neck long, bill pointed, beak broad, feet webbed. Habits: Swims, lays eggs, makes its nest on the ground, walks awkwardly, brave in action, loves to wander in the fields, looks for its food in water, in mud. Uses: Flesh, food; feathers, beds, pillows; quills of feathers, pens, toothpicks. Literature: "Feathers and Fur," Johonnot; "The Goose That Laid the Golden Eggs," "More About Geese," "Verse and Prose for Beginners."

THE CATERPILLAR.

Interesting way to teach successive steps in the life of the caterpillar. Teach the song:

" A caterpillar is on the ground,
It creeps and creeps and creeps around:
It's building now a nice, warm nest,
Where it can find a place to rest.
Dear caterpillar, we'll say good-bye,
Till you come out a butterfly.
Oh, there it is! oh, see it fly!
A lovely, lovely butterfly.
It spreads its wings, so dazzling bright,
And seeks the joyous air and light;
'Tis sipping honey from the flowers,
Dear little butterfly, you're ours."

From the children try to get the answers to the questions: Where the caterpillar is found? What is its food? Caterpillar always found on the plant from which it gets its food. Shape of body? Rings? Feet? When does it stay with us? What does it do in the autumn? How does it spin its cocoon? How long does it sleep? What it develops into? Compare butterfly and moth. Speak of silk worms.

Literature: "Insects at Home," Hood; "Such a Beauty," in "In The Child's World," E. Poulsson; "Butterfly," "Butterfly's Lesson," "Butterflies," in Lovejoy's "Nature in Verse;" "Life of a Butterfly," in "Cat Tails;" "Life and Her Children," Arabella Buckley.

The metamorphosis of the butterfly: First, when out of egg, a caterpillar; caterpillar grows, sheds skin frequently; last time skin becomes hard; spins cocoon; caterpillar seems to sleep (chrysalis state); finally out of the cocoon comes a beautiful butterfly; butterfly lays eggs. This a complete metamorphosis.

Kindness to animals can be inculcated by the study of appropriate memory gems: A bird day is an advisable thing; How wrong it is to steal an egg or nest; How we would feel if carried away from our family; If our home were snatched away from us. Form a society for the prevention of cruelty to animals. Its motto: "We will form an active band."*

Natural phenomena, sunrise and sunset: Get a mental picture of child's idea of sunrise. The color of the sky, where the sun rises, how night disappears, how daylight comes, how everything awakes,

*Selection to be found in "Hours With Nature," Second Book, published by Potter & Putnam.

how the birds say "Good morning," how the flowers awaken, how the laborer works from sunrise to sunset. "The Sun's Travels," Stevenson; "Awake, Said the Sunshine," in "Songs for Little Children," Smith.

SUNSET.

Mental picture of child's idea of sunset: Where the sun sets, how night appears, how the daylight disappears, how all things prepare for rest, birds go to their nests, chickens roost, cows return from pasture, animals go to sleep in the fields, horses led into the barn, children go to bed, parents, grown people, go to bed.

With the lessons on sunrise and sunset; facts emphasized: Sun rises in the morning, sun rises in the *east*, at noon, sun in the *south*, at night, sun in the *west*, sun sets in the west, sun's rays illustrated by prism; show a broken ray, six parts; color of each; when prism is away; one stretch of white light.

LITTLE TALK ON SEEDS—DISTRIBUTION OF SEEDS.

How scattered? By the wind, in clothing of animals, by water.

A little talk of how the seed, carried far, far away by the wind, took root in the place to which it was blown.

How the sheep in its wool carries seeds along; how seeds float along, stop at a certain point and then take root. Speak of the long, long sleep of the flowers; the snow, the protecting blanket; the change of the seasons; spring; spring literature.

THIRD YEAR—SECOND HALF.

Methods and conditions of planting and harvesting. When to plant? when to sow? best condition of soil? why they are best conditions? nature's helpers after planting.

Harvesting: What season of the year? how harvest is gathered in? why?

Recognize trees by fruits and leaves. Fruits and leaves should be brought into class; same kinds of fruits placed together, same kinds of leaves placed together. Give a few names, familiar ones if possible; from observation, reading, or information gained by question some trees are known; have the unknown compared with known; give names of the new; ask children to look at new carefully, bring a specimen of same kind for the next lesson. These lessons must not be too long; do not weary the children.

PARTS OF A FLOWER.

Calyx, corolla, stamen, pistil. Calyx means cup. That into which the colored part of the flower sets is almost shaped like a cup. Corolla is the colored part of the flower. Corolla means crown.

Show corolla. Stamens: in some flowers the stamens grow fast upon the lowest part of the corolla; in others the flowers are next inside the corolla; the stamens are slender, thread-like parts. Pistil: the pistil is the body in which the seeds are found. Calyx: sepals, outside leaves; corolla: petals; stamens: pollen, powder-like stuff on the anthers; anther: little head at the top of the stamen; pistil: style, tall, long part; stigma: large part at the very end; ovary: the seed box.

Along these lines germination should be observed. Life history of the plant.

Different animals are to be found in the different zones. In the temperate zone: The horse, the cow, the ox, the grizzly bear, the lark, the robin. In the frigid zone: The seal, the walrus, the whale, the reindeer, the bear, the white fox, the ermine. In the torrid zone: The lion, the tiger, the camel, the giraffe, the monkey, beautiful butterflies, birds of gayest colors. "Plants," Gray's Botany; "Natural Phenomena," Geike; "Elementary Physical Geography," Tarr; "Earth Study," easily found in any good geography; "A Popular Geology," Katherine E. Hogan.

The moth from the caterpillar should be illustrated in class; the frog from the tadpole, also in class; migration of birds, refer to "Winners in Life's Race," by Arabella Buckley; "Natural Phenomena;" "Earth Study," Physical Geography, Geike.

Introductory Lessons on Plant Life—A Series of Six Lessons for Little People.

By Ella K. Jelliffe, Instructor, Brooklyn, N. Y.

I.—The Purpose of Plant Life.

LET us take a walk into the country, this afternoon, children—not a real walk just now, but only a "make believe" one—and let us talk of the grass and the flowers and the trees that we see on our way. They have all been asleep—such a long sleep! —but now they are waking up. Last night it rained and away rolled the last bit of the warm, white blanket which had covered the shivering trees and the naked grass; they awoke and drank greedily, for they were very thirsty. Now the sun is smiling down upon them and the grass peeps up and gleams at the sun through tears of joy; the trees, too, have lost their forlorn and bare look and have tiny buds of delicate green beginning to blossom on their branches.

Do you like to guess riddles? Well, I'm going to give you a hard one, so put on your thinking caps and try to find the right answer: What good are the trees and the grass and all plants? What are they for? "To please us." Well, they surely do please us and make the earth very beautiful. Recite your quotation about the beautiful world for me, please:

" Great, wide, beautiful, wonderful world,
With the wonderful water round you curled,
And the wonderful grass upon your breast;
World, you are beautifully drest! "

But I must tell you what another poet says,

" Full many a flower was born to blush unseen
And waste its sweetness on the desert air."

It is true, boys and girls, that flowers and trees could be found

" Springing in valleys green and low,
And on the mountain high,
And in the silent wilderness
Where no man passes by."

And I'll just whisper to you a strange fact—there were flowers and trees and plants of different kinds on the earth long before there were any little boys and girls; so that first answer can't be the right one.

"Just to grow," one little girl says, "that's what plants are

for." Indeed, they do grow and they seem to be trying to fill their place in the world just as we live and grow and try to do our duty in the place where God puts us. There is, however, a greater reason still for the life of plants.

Let us think of trees alone. Tell me some of the uses of trees. "They give us shade." "They give us wood to build houses and ships and other things." "Things to eat grow on them." These are all good answers. Tell me some of the things which are good to eat and which grow on trees. "Apples, pears, peaches, plums, oranges, nuts." Very well. What do you find inside these fruits? "Seeds." What are the seeds for? "New fruits grow from them." Ah! now we have answered the riddle; we have found out what plants live for. They live and grow and produce fruit with seeds from which will grow new plants of the same kind; and so the world will keep on being beautiful with trees and plants.

Do you think we could live without plants? (I have told you that they could live without us.) This is another riddle which I am giving you to solve but I'll help you again by asking questions. Will you tell me, Amy, what you had for your dinner to-day? "Meat and potatoes and rice pudding," Well, where do potatoes come from? "They grow;" and the rice from which the pudding was made? "It grew, too." "The meat doesn't grow," Freddie says. "Meat comes from animals." Yes, but what would animals do without grass and other plants? "They couldn't live." Think what we have found out to-day, children—there could be no animals and no people without plants. Aren't you glad that they grow and keep on growing?

And now that winter is going and spring is coming, think of all the things waiting to grow:

"Little white snowdrop, just waking up,
Violet, daisy, and sweet buttercup!
Think of all the flowers that are under the snow,
Waiting to grow!"

II.—Seeds.

"And think what hosts of queer little seeds,
Of flowers and mosses, of ferns and weeds,
Are under the leaves and under the snow,
Waiting to grow!"

To-day we are to talk of seeds. Did you know that seeds are like men and birds? They are very fond of travel; men like to see new countries; often they think it best to try life in a different place from the one in which they were born. They think they may have

better opportunities, greater chance to succeed. Birds, too, flit from place to place—to warm places in the winter and to cool places in the summer, though there are some birds who do not mind the cold at all, and others who enjoy the heat.

Well, plants, too, travel; that is, they send out their seeds as birds send out their young and as human parents let their children start out to begin life for themselves; and they have as many different ways of traveling as men have. Tell me some of the ways in which men travel. "On foot, in cars, in boats, in carriages, on horseback;" yes, and they have even tried it "in balloons."

Now let me tell you some of the ways in which seeds travel; and it is a curious fact that most of them are anxious to go quite a distance from home. Shall I tell you why? They need new ground where they can get good food, for perhaps their father and mother used all the food in the home where they raised their family, and now each young member must go and earn more.

Each plant takes from the ground just the kind of food it needs in the same way that each organ of our bodies takes from the blood that circulates in us, the particular kind of food which best suits it.

But to go back to the seeds—such curious ways they have of traveling. Apple seeds travel far; what wily little creatures they are! They wrap themselves up in beautiful red or yellow balls, and people are attracted by them, taste them, and, finding that they are good, eat them and throw the seeds away—just what the sly little things wanted. And, oh! barrels of apples have been sent far away and these gay young travelers are happy.

Some seeds go sailing in the air, as ships do in water. You know the dandelion, that comes among the early flowers, that—

> "Dear, common flower, that grow'st beside the way,
> Fringing the dusty road with harmless gold;"

what does it look like in the autumn? "A fluffy ball." "We tell what o'clock it is by blowing it." Yes, and as you blow it you can see each little seed-boat sailing away in the air, and perhaps the wind takes hold of it and carries it far off and drops it down in some pleasant pasture, where next summer it will peep up through the grass with its bright yellow eye and gladden some other little girl or boy—perhaps your cousin, who lives many miles from you.

Some seeds have wings and imitate the birds as they fly through the air. Have you seen the wings of the maple tree? They are the fruit of the tree, though we do not find them good to eat. In the autumn they fall to the ground, but when the November winds

come they are lifted up and away they go, flying along like birds bound for a new home.

I would like you to become acquainted with as many of these plant-children as you can and study their habits. Look for the elm trees' children and the pines'. What is the seed of the oak tree called? "The acorn." It looks like a nut, but we do not eat it; who does? "The squirrel." I was walking in Prospect Park one day in November; my carpet was fallen leaves, a soft, rustling carpet; occasionally I stepped on something round and hard. Stooping down I found glossy acorns, in their daintily carved cradles, and I thought, "Oh, the squirrels should be on hand to store these up for the winter!" and sure enough, there came a squirrel, with tail longer than his body, down the trunk of a tree the same shade of gray as his fur, and rustling through the leaves; he stopped and stood erect and looked at me as if I were an intruder, then darted behind the tree and back again, flitting to and fro till I moved away. At last he sprang forward, in his alert way, seized the acorns, stowed them away in the pockets in his mouth, and then carried them to holes in the trees, where he hid them for the winter. What a busy, clever little creature, saving for a rainy day!

Will you think about seeds and learn all you can about them? I shall be glad to hear of your discoveries at our next lesson. I should like you particularly to find out the names of some seeds of trees which we eat. Remember, though, that neither we nor the squirrels eat all of these seeds, or there would be no more trees of their kind. Some seeds are lost or dropped, and Mother Nature finds them and takes them in her lap.

There are other ways that seeds travel; some are thrown or shot out of their homes, as certain birds throw their young out of the nest to force them to use their wings, and as some parents throw their sons into the water to teach them to swim. Though this seems cruel, it is done for a good purpose, and generally it is done only to those who are able to stand it. I wish you would try to find out the names of some plants that force their babies out into the world this way.

Some seeds are like certain poor or naughty boys who wish to travel and can't pay their way, so they steal rides or are stowaways. I have found seeds in my dog's hair and on my own clothes, and they have come all the way from the country to the city with me. Have you ever given seeds a free ride in this way?

If you will try to answer all these questions at our next lesson, I shall read you such a pretty story about "Treasure Boxes."*

* "The Stories Mother Nature Told Her Children," Jane Andrews.

III.—Baby Plants.

This morning, girls and boys, I am going to tell you a story; it is as wonderful as a fairy story, but the best of it is that it is true, and you can prove it for yourselves, for I'm going to tell you how. Last week we were talking about seeds and of how they traveled about from place to place. To day I'm to tell you what is inside the seeds. But will you tell me first what is inside the egg which the mother-bird keeps so warm? "The little bird." Well, inside the seed is a baby plant. "How do I know?" I opened one of the seeds and saw it; but I had to use a magnifying glass, for I couldn't see such a tiny thing with my own eyes alone. I saw more than the baby plant, too. I saw baby food all prepared for it to eat. Isn't it wonderful? Now do you want to see all this for yourself? I'll tell you how. Get some beans and lay them on some cotton wool in a glass of water. At the same time we'll plant some beans in a pot of earth, and we must keep the earth moist by watering it every day. Watch the beans in the glass of water, and in a day or two you'll see something strange. Tell me about it when it happens, and then we'll keep watch on the pot of earth, too.

When a seed falls into the earth in the autumn, it lies there all winter and keeps eating the prepared baby food, which its kind mother put in its cradle; and it gets a little air—all it needs—through the pores or tiny openings in this same cradle or seed-shell, and then when spring comes and the ice and snow begin to melt and the rains come—oh! how grateful the thirsty little plant is! It drinks greedily and then it begins to grow in two ways, down into the earth, taking firm hold, and up into the sunlight, for from both the earth and the air the plant gets its food.

"High and higher still it grows
 Through the sunny hours,
'Till some happy day the buds
 Open into flowers."

IV.—Roots and Stems.

"Think of the roots getting ready to sprout,
Reaching their slender brown fingers about,
Under the ice and the leaves and the snow,
 Waiting to grow."

Let us pull up one of our bean plants very carefully so that we may see what it has been doing underground. Ah! we see a bunch of tiny roots like little thin fingers; that's the way the bean held on to Mother Earth, and it is through these little thread-like roots that the young plant gets its food, through them it sucks up the

moisture formed in the earth by the spring rains and it takes a little earth food, too, having a wise little way of its own of preparing it.

All plants do not have the same kind of roots. Some of the vegetables which we eat are roots—fleshy roots. Can you tell me some of them? "Beets, turnips, radishes, potatoes." Right, except that the white potato is not a root but a stem. However, I had to be taught that for I, too, thought it was a root. Stems do not always grow above ground, some of them grow under the ground. If they have buds or leaves on them, they are stems. Has the potato buds or leaves? No, but it has "eyes," which are really buds from which new potatoes grow.

All parts of the plant spring from the stem—even the root grows from it, as you noticed in watching the bean grow. First the stem comes, then one part of it bends down into the earth and the other part straightens itself out and grows upward.

There are some plants that cannot stand alone but must cling to something for support. Can you tell me some of these? "Morning glory, grapevine, ivy." Some day I'll read you a story about "The Oak Tree and the Ivy," written by a man who loved children and whose name is easy to remember—Eugene Field. If I should forget to read it to you, you may remind me of it.

Some stems creep along the ground. Can you think of any? "Strawberries." Some are held up by the water. Do you know the water-lilies? After the dainty white lily, with its heart of gold, has bloomed for us and made all the air about fragrant with its perfume, "The stem that found its way so surely to the upper world knows not less surely the way back again, . . . and when it has wrapped its green cloak about it again, not to be unfolded, the stem coils backward, and carries it safely to the bottom, where its seed may ripen in the soft, dark mud, and prepare for another summer."—(Jane Andrews.) Most stems, though, stand erect like the trunks of trees and the graceful Indian corn, of which I must tell you some day.

To close our lesson to-day, I'm going to read you a story about a dear little traveler in the underground world. He has a very queer name, but then so have some of us; so when I introduce you to him you must try to remember his name, that you may know him when you meet him again. "How Quercus Alba went to explore the underground world, and what came of it."—(Jane Andrews, in "Stories Mother Nature Told Her Children.")

V.—Leaves.

Bring me some leaves, children, as many different kinds as you can—rose leaves, lilac leaves, honeysuckle leaves, maple leaves, oak

leaves, leaves of fruit trees, clover leaves. Each one of you bring at least two leaves and we shall have a delightful drawing lesson on Monday.

Now, have we all brought our leaves? Good! Do you notice that I have drawn pictures of mine on the blackboard and I have put their names above them. Let us see how many of them we know. Who has one like this? (Oak.) Yes, yours is an oak leaf, too, but larger than mine. Who has a maple leaf with its three points? Who has a clover leaf with its three leaflets?

And what have you, Jennie? "A geranium leaf." I didn't bring one of those; let me draw yours, please. I have one like yours, Bessie, what is its name? "Rose leaf." Can you find its picture on the board? What kind of a leaf have you, Robbie? "A leaf from an apple tree and one from a lilac bush." Oh! you have your two leaves and you have pressed them so carefully; do you think you could draw a picture of the lilac leaf on the blackboard? Class, do you think you would know that it is a lilac leaf? Yes, indeed, he did it well. Now, each one of you try to draw your leaves on your paper and let us set to work to learn the names and shape of as many different kinds of leaves as we can by gathering leaves of different trees and flowers, asking about them, tracing them on paper with pencil, noting whether they have smooth edges, teeth-like edges, and whether their veins run all in one direction or every which way like a network. By and by you will learn how very important leaves are to the plants. They couldn't breathe without them, and they couldn't get enough to eat and drink without them. They are great workers, and they are so arranged on trees and flowers that one doesn't interfere with another's sunshine, and the rain pours off of them just in the right place to give the roots under them in the ground plenty to drink.

A little girl I know has a pretty nature book, in which she has pasted many different kinds of leaves which she gathered and pressed. Underneath each she wrote its name, and now she can draw nearly all of them from memory. She kept leaves of trees by themselves and fruit leaves and flower leaves separate. Will you try to keep such a book and keep adding leaves—new kinds—every chance you get?

VI.—Flowers.

Let us study a little flower to-day. I have brought a bunch of wild flowers; I'll place them in a glass of water on my desk. Now, let us take one of the little blossoms and try to find out how it is made. First, there's a little green cup which is called a calyx—do you think you can remember that word? People who lived far away in a beautiful country used that word for cup; they spoke a

different language from ours. This green calyx is divided into five parts or leaves. Above this cup is a crown of white leaves. This crown of leaves is called the corolla, another strange word. Let us count the leaves of the corolla. Ah! there are five of them, too. And what are these little thread-like things inside the flower; they look like pins, for, see, they have heads! But one of them is different from all the others. That middle one is called a pistil, and the others whose tops are full of yellow dust like little golden-haired fairies are called stamens. Now, let us go all over this again, for we would like to know how these flower houses are built and what each different part is called. We shall find some or all of these parts in every flower, and by studying them carefully we shall know how to place them in families.

The flowers are not all made alike, but they differ from each other as animals differ. The monkey is not like the rabbit, the elephant is not like the dog, but tell me some animal that does look something like the rabbit. "A hare," "a squirrel." And tell me some animal that resembles a dog. "A wolf," "a fox." Yes, and those animals are related to each other. In the same way flowers are related to each other. Some of them have brothers and cousins. Shall we not study some of the flowers and find those that belong to the same family? Can each of you bring a flower for next lesson and we'll have a party of flowers? Violets and pansies, roses and lilies, buttercups and daisies, the wild geranium and columbine. and as many more as we can bring. When we send out our invitations to the flowers to come to our party, if any of them are away from home, traveling, and can't arrive in time to attend, I know they'll send cards regretting they can't be with us, and I'll place them on the blackboard so that we shall have the pleasure of reading their names. Have you brought your flowers, children? Oh! I'm so glad you didn't forget. You have violets, Jennie, haven't you? Did you go to the woods for them? And, Amy, you have pansies—let us sing about them, children:

" The dear little pansies are lifting their heads,
All purple and blue and gold;
They are covering with beauty the garden beds,
And hiding from sight the dark mold."

"They grew in mamma's garden"? And where did you get your lilies-of-the-valley, Arthur? Aren't they sweet? Ah, Robbie, you have been to the country, have n't you? What a beautiful bouquet you have. Here are buttercups and daisies! Did you go on an excursion as I did, Henry? See what I brought home with me! Ox-eyed daisies and a branch of the beautiful mountain laurel tree;

the flowers are open now, but they were all closed up, asleep, when I called them to come to the party.

I did as I promised and put the cards of those who couldn't come on the blackboard. They would have come if they could, but some had gone away, as jack-in-the-pulpit, who had to preach in another country, and will not be back till next spring. He took the trailing arbutus and the anemone with him to sing in the choir. Golden-rods and asters sent regrets, too, for though they are traveling toward us, they have not yet arrived. The fringed gentian barely got his card here in time, for he is a long way off, being the last flower of the year. Listen to what one of our poets says of the fringed gentian:

"Thou waitest late, and com'st alone,
When woods are bare and birds are flown,
And frosts and shortening days portend
The aged year is near his end.

"Then doth thy sweet and quiet eye
Look through its fringes to the sky;
Blue, blue, as if that sky let fall
A flower from its cerulean wall."

Now let me pin a pretty fresh flower on each boy's coat and on each girl's dress; and will you take them home and press them? And to-morrow I'd like you to draw their pictures from memory.

A Study of Germination.

By Lillian C. Flint, Instructor, St. Paul, Minn.

THE conditions necessary to bring about that change in a seed known as germination are two, namely, heat and moisture. This starting of the plant in life from its parent seed may begin either under or above the ground, or it may begin in any substance that will give moisture and a temperature that is but little above freezing.

Seeds usually have two parts: the seed coats, which consist of a thin skin over the outside of the seeds, and the inner portion, which subsequently develops into the seed leaves.

In all seeds, at the beginning of germination, the first change noticed is a slight enlargement on one side and the breaking forth of a tiny organ called the radicle, which begins to circle, and this movement continues as long as growth continues.

Now gravitation, the force that constantly acts on all bodies, takes hold of it, and the radicle bends downward and endeavors to penetrate the ground, following a more or less spiral course. To effect this, it is almost necessary that seeds be pressed down, in order that they may offer resistance, otherwise the radicle is lifted up instead of penetrating the surface.

To make clear the terms that are used in this article, it may be well here to name the parts of growing plants by their technical names. The cotyledons are the seed-leaves, the stem immediately above them the plumule, and the part below the radical, which can be distinguished from the root by the presence of root hairs on the root.

Nearly all seeds are covered, often by earth thrown up by burrowing quadrupeds or scratching birds, by the castings of earthworms, by the blowing of dirt or decayed leaves, the decaying branches of trees, and thus they will be pressed down so that when the radicle starts it gets a purchase. Even with the seeds lying wholly above the surface, the first developed root hairs, by becoming attached to stones or other objects, are able to hold down the upper part of the radicle, while the root penetrates the ground.

These root hairs, with wonderful adaptability, attach themselves to the most irregular particles of the soil so firmly that they are not easily detached. They do this by first softening the outer wall of the hair, sticking it to the desired surface and then hardening.

Now the brain of a plant is this same radicle, and all through

the life of the plant it is the directing force. It is easy to make it give up its secret. After a bean has been soaked so that the slight swelling is perceptible at the side, put a pin through the fleshy part and fasten to a wall or other plane surface. Then suspend some object so that it will just touch the tip of the bean.

Within a short time of touching it will bend away from the object touched. Many organs touched will bend toward the touching object, but there are none that we know of that will bend away from it. This movement of the tip of the root away from an object is an entirely different mode of procedure from that followed by any other part of the plant.

It does not stop the growth of the tip to touch, it only changes the direction of its growth. But there is that other force which never stops acting, namely, gravitation; and as soon as the tip has passed the obstruction, it again takes hold and pulls it toward the centre of the earth. Again the circling movement, which all plants have to a greater or less degree, comes to its assistance, for the tip, while trying to bend to all sides, discriminates between harder and softer soil and follows along the line of the least resistance.

If the tip of a plant were not sensitive, and if it did not bend away when it touched anything that obstructed its path, the roots would become crippled and dwarfed, so as to be almost useless as bread winners for the plant. Of course, the trial trips which the tip takes determines the final course of the root, and it is necessary that it should have discrimination enough to take the most advantageous direction, hence this location of the management of the domestic economy of plant life.

Now it is easier for a thick, strong radicle to make its way in the world and overcome obstacles than it is for a weak, delicate one, so those with strength have less sensitiveness than the weaker. They can push aside obstruction, while the weaker radicles either have to go around the hindrance or yield to it.

This capacity for bending away from anything that opposes its progress is a beautiful adaptation to environment and reaches the radicle capable of getting the very most out of its location.

But the power to bend away from obstacles is not the only faculty that resides in the tip. It will turn toward water and toward rich soil, so that it takes the plant which it controls into the best attainable feeding ground.

Leaving now the seat of control and management of a plant, we come to its first appearance above ground. In the two-leaved seed, this is in the form of an arch, and if we look at it closely we shall see that it has come up in the most direct manner possible. We

all know the action of light on a plant. and it has shown itself of service in directing it the shortest way to the surface of the earth.

There is a logical reason for a plant coming up in the form of an arch. In the first place it comes up with twice the force that it could exert if it were straight, for as both legs of the arch grow its power of breaking through the soil will be increased, at least as long as the tip of the plant remains within the seed coats so that the tip can get a purchase to help it along.

Besides the advantage of getting the extra force attained by coming up with two legs, there is another advantage to be gained in this method of making its way out of the ground. Close-packed within the broad protecting seed leaves lies the tiny delicate plumule, likely to be injured by the slightest friction, and done to death by the falling upon it of grains of sand or dirt which it is liable to meet in getting to the upper world.

But hidden down here, the arching tendency gives it the means of backing up into the light and sunshine, and getting a start before it is injured by the dangers that lie in wait for most plants in their struggle for existence. Perhaps this arching was first caused by the confining of the seed leaves within the seed coats, or the friction while being dragged up. But be this as it may, the plant must have soon found out that the benefit of this method of procedure was incalculable, and it became ingrained and fixed in many plants. This habit of arching is probably of exceedingly ancient origin.

The plant accomplishes the mechanical part in a curious way, and yet in the simplest way that it could be done; it just grows a little faster on the outside of the arch and for only a little while, that is, the increased growth on the convex side of the arch soon ceases and is made up by the rapid growth on the concave side and by this means the plant straightens itself and stands upright.

At first both legs of the plant grow, but as soon as it has gotten above the ground this ceases, and all the work is done by one leg, or that by which it is united to the radicle.

The seed leaves often emerge from the ground tightly packed and covered by the seed coats, which still give them their protection. But now, their protection being no longer needed to help them in their progress, they are gotten rid of by the swelling of the cotyledons and drop to the ground. Not only are the seed coats gotten rid of because they have served their office but there is another stage arrived at, which must help in the business of life.

The seed leaves, with their large, fleshy forms, contain the nourishment of this infant, but even in this state it is hardly edible for the newcomer; it must be softened and rendered capable of being absorbed by the baby plant. Now come in the sun, rain and

air, and, liquefying this stored up material, they render it just the best food that could be provided and in such a condition that it can be absorbed.

As before stated, the seed leaves are forced off by the swelling of the seed leaves, and not by any movement of the plant. But while this is the case in ordinary plant families, there is a class that has by some means discovered that the sooner it got its stored-up food where the baby plant could get it to use, the more would the prosperity of the family be increased.

This is the cucumber family, and to this order belong the pumpkin, melon, squash, and so forth. It has grown a curious contrivance, and while still the seed coats are buried in the ground, just at the base comes out a small peg or wedge, which, lying on the lower part of the seed coats, pushes them off, so that as soon as the seed leaves are above ground they can begin their work.

With this wedge to hold down the lower part of the seed coats and the continued growing of the arch, the coats are torn apart. It would hardly seem possible that the plant should have found that this method would have given it such an impetus in the race for life, but there is no doubting that this is just what the special contrivance for getting rid of its seed coats a day earlier is worth to it. It is, like many other devices of the plant, a matter of succeeding or failing.

If we tear off the peg and let the plant shed its seed coats by swelling. as do ordinary plants, the decrease in superiority to those that retain the peg is soon seen. It does not rest on the upper part of the coats, for there it would have not benefited the plant, neither is there a corresponding growth on the other side of the arch; it is put just where it will work, and it grows in about twenty-four hours. The broad seeds of this order lie flat on the ground, and it would require considerable force to lift this weight above the earth. Moreover, the weight of the seed with the coats, in this class of plants, is much greater comparatively than with other plants, and so the sooner they are disposed of the less weight will the young plant have to carry and the more force can it give to its growth.

But there is another artifice which a class of plants has seen fit to use, which is quite as interesting as the device of the peg. The *Megarrhiza Californica*, a member of the bean family, has a most extraordinary method of germination. As it lies above ground, it is very likely to be eaten by animals, both in its first stages and later growth; so instead of letting the plumule come up between the seed leaves, it has developed a method of sucking the nourishment laid up for its nursery period, down into the radicle; then the tiny plantlet comes out through a little slit in the side of the radicle and

quickly makes its way up to the sunlight, protected by having a subterranean storehouse for its sustenance, instead of having it at the mercy of every prowling bird or quadruped.

With the single-leaf family there is no arch, but they are well adapted, with their sharp points, for piercing between the particles of soil and making the very quickest way to the light. And they are not left wholly without means of forcing their way upward, for there is at the tip an aggregation of cells which renders it stronger and assist in breaking through the earth.

In bulbs, the folding together of the thickened leaves into the form of a cone, aids materially in giving them strength to come to the surface.

There is another ingenious method which the plantlet has adopted, and which is not only of wonderful utility to it but in many cases a matter of life and death. That is the so-called sleep. This closing of the leaves, so that they might escape the effect of detrimental outside influences, was noticed as long ago as the time of Pliny.

In the young plants the leaves are pressed together so that their upper surfaces are in contact. In the seed leaves, during the first four or five days, there is no movement, which is remarkable, and has not been fully explained. But after this the nightly rise begins about four or five o'clock in the afternoon.

If some of the leaves are kept awake by artificial means, the amount of dew deposited upon the exposed surfaces will be seen is much greater than on those closed. Evidently the benefit to be gained is to prevent radiation, and thus hinder injury by cold to the plumule and to the delicate upper surfaces of the leaves.

Thus, these sturdy little agriculturists, by adapting themselves to their environment, have tended to bring about a marvellous development in their line. They are enabled to get what they want and to get it easily, through their inherited tendencies. They get the best out of life by a manner which acts in them as instinct does in the higher animals.

Aquaria: Their Construction and Equipment.

By Harriet H. Wilder, Professor of Zoology, Smith College.

IN CONSIDERING larger aquaria, or rather those fitted for the reception of larger animals, we come upon three problems: (1) the selection of a suitable container; (2) how to prepare it for the reception of the animals, and (3) what animals to select. A containing vessel is liable to two evils, which must be avoided as far as possible: a tendency to distort the object viewed and a tendency to leakage. The first of these can never be entirely overcome, owing to the difference of the refractive indices of water, glass and air, the three media involved in an observation; but it can be greatly reduced by the employment of either an aquarium with straight sides or a cylindrical one so large that its curvature is not very great. The small globular aquaria, filled with gold-fish and employed for ornamental purposes, act as huge spherical lenses, and cause both the magnification and distortion of the enclosed fish, often to a laughable degree, a circumstance which may possibly enhance their value as bric-a-brac, but which deprives them of most of their scientific worth.

The best, but at the same time the most expensive aquarium, is one shaped like a box, with a heavy zinc-lined compartment serving as a foundation, and with a wooden frame in which the glass is set as in a window-casing, but with a firm waterproof cement instead of putty. Such aquaria have, however, the disadvantage of being quite expensive, and in spite of many precautions, they are apt to spring a leak at the lower edges of the glass, often after the aquarium is fully stocked and the relation of animal and plant life well adjusted.

Both of the above disadvantages are obviated in a comparatively new article manufactured by Whitall, Tatum & Co., of Philadelphia, and obtainable directly from them at prices ranging from $1.50 to $5.00. This consists of a box-shaped, glass receptacle, moulded in a single piece, and thus entirely without joints or cracks. They may be obtained in several different sizes and proportions, and the larger ones have glass knobs upon the sides to serve as handles. The same firm manufactures, also, cylindrical jars of many sizes, with the upper edge nicely finished off by a thickened and rounded lip. Of these the smaller sizes are suitable for the first sort of aquaria mentioned, and the larger are useful for containing fish and other sizable forms.

Having selected a container, it should next be made ready for the reception of the animal inhabitants, which is best achieved by *copying the natural environment as closely as possible* and producing a small sample of an outdoor pond. Supposing the aquarium selected to have an inside depth of about 14 inches, the various ingredients forming the bottom may be put in about the proportions suggested here. Into the dry-glass container there is first put in a layer of good garden soil about 2 inches deep, and in this are planted two or three specimens of some aquatic plant with roots, such as *Chara* or *Nitella,* or perhaps a tuft of some very aquatic sedge; in short, any little aquatic plant found in the locality to be imitated. Above the garden soil is placed a layer of perhaps an inch of clean, freshly-washed sand. The sand may be washed in any large pan or tub, the water being drained off after the sand has settled, and this process repeated several times. It is perhaps a little more convenient to have the sand perfectly dry at this stage, merely for the sake of being more easily handled; but this is not at all necessary, and rests with the convenience of the one preparing the aquarium. The sand should be placed tightly around the stems of the water plants, as in the illustration. Lastly, upon the layer of sand comes a final layer of either coarse gravel or small pebbles, and if the aquarium is sufficiently large, two or three quite sizable stones may be placed in a heap in one corner, piled in such a way as to form one or two small caverns or places of concealment, which will be much appreciated by the future inhabitants. In some cases this edifice may be built up to nearly the surface of the water, thus furnishing a support for a small turtle, salamander or other creature not wholly aquatic, and which would drown in an ordinary aquarium. The placing of one or two shells or bits of coral on the bottom is, perhaps, rather amateurish, but where the main object is to make an aquarium attractive, may have a legitimate use. Such objects, however, should not be introduced until after the water has been added. and is thoroughly cleared, since, otherwise, they would become so covered with dirt and sand as to be almost unrecognizable.

When the construction is thus far completed, the water is next to be introduced, and in this the greatest care should be exercised not to disturb the sand or earth, and especially not to allow the water to bore holes in it. Where a faucet is available, the water may be conducted from it to the aquarium by the employment of a rubber tube, and the free end of the tube should be so placed that the flow of water is received upon the surface of a stone placed there for the purpose. In other cases water may be siphoned in from a pail, still using the tube in the way suggested, and when no other way presents itself it may be introduced slowly by a small dipper

or pitcher, the wafer being slowly poured over the stone, as in the former case. Since, even with the greatest care, the soil will be more or less stirred up and the water in consequence become somewhat turbid, it is best to leave the aquarium at this point until the following day, when the water is to be entirely removed and replaced with fresh, as carefully as at first, thus washing the soil and gradually eliminating the free particles that cause turbidity. The removal of the water should be accomplished by employing the rubber tube as a siphon and receiving the water in a pail, or, where no tube is to be had, it may be carefully dipped out. This process of removing the water and supplying new should be repeated each day for several days, until the water, when settled, is as clear as may be necessary. An absolutely crystal clearness of the water is not to be desired, as it does not obtain in the natural ponds of which the apuarium is to be a copy, and aquatic animals live better in water that is not quite clear.

When the aquarium is in a satisfactory condition it may be stocked with whatever aquatic animals are desired, and, provided there is a sufficient quantity of plant life, and not too many animals, it will not need very frequent attention. It will be well to place upon the surface a few floating aquatic plants, such as the little *Anacharis*, with its two or three small oval leaves, and not forgetting some green pond scum (*Spirogyra*), etc., which will serve as food for many of the animals, or for the minute crustaceans and other forms which develop in such places, and which, in their turn, serve as food to the larger inhabitants.

The subsequent care of such an aquarium depends upon the kind of animals with which it is stocked and the end to be accomplished. If, as in the case of the smaller aquaria, the more minute forms are to be preserved, and their development encouraged, to serve either as food for the larger animals or as an object of study in themselves, the water should be changed but seldom and then but a little at a time. The author possesses a small aquarium in a jar, employed for the purpose of developing *infusoria*, and which has been kept perfectly clear and free from bacteria for nearly two years by simply keeping the top covered, and without any change of water whatsoever.

This instance, here introduced merely by way of illustration, shows clearly that the importance of changing water under all circumstances is apt to be greatly exaggerated, for, although in this case, the animals preserved are of minute size, it is probable that a single small fish or other aquatic animal of small dimensions, could have been kept alive in the above-mentioned jar for at least several months. Again, not all truly aquatic animals depend upon the air

contained in the water, and thus forms like turtles and the amphibia could live contentedly in an aquarium almost deprived of its oxygen, the main requisite being to prevent the accumulation of bacteria. Even among fishes and others which depend entirely upon the free oxygen in the water, the amount necessary varies very much, and some species will be very uncomfortable or will even perish in water in which other species find but little inconvenience.

There are two methods commonly employed in introducing fresh oxygen into an aquarium: (1) aëration, and (2) change of water. The methods of effecting the latter have already been commented on, as they are the same as those employed at first, while preparing the aquarium for use. The frequency of this operation, as pointed out above, depends upon so many things that no definite rules can be given, but the general opinion is apt to exaggerate the necessity. In an aquarium of moderate size, and constructed like the one described above, the removal and replacement of a pitcherfull twice a week is ample, even when well stocked with fish, and the larger the amount of plant life, the less important is the change of water. Aëration, the other method, consists of some device by which bubbles of air are forced through the water, thus allowing a little of the former to be absorbed during the passage. For this purpose various methods are employed, varying from a simple apparatus that can be constructed in any laboratory to elaborate and more or less expensive outfits which may be obtained from dealers. These depend in general upon a flow of water, from either a faucet or in some other manner, so arranged that bubbles of air become imprisoned in the tube through which the water first flows. The water employed in this apparatus has a wholly mechanical use, and is drained off into the sink while the air is forced along a second tube into the bottom of the aquarium. Such an aërating appartus may be arranged to deliver air at the rate of a bubble at a time continually, or may be allowed to deliver it much faster during definite intervals. A large aquarium in the author's laboratory, with dimensions of about six feet by three feet and a depth of two feet of water, and stocked with very many fishes and other aquatic animals, is kept in excellent condition by a vigorous aëration of two hours each, three times a week, and a change of about two thirds of the water by means of a siphon once a week.

The next point to be considered is that of the selection of animals, and concerning this the briefest and most universal rule is to select the animals from the same sort of natural localities which have served as models in the construction of the aquarium. In doing this there is danger, of course, that the smaller forms will be devoured by the larger ones, but one may be assured that whatever

of that sort happens is a perfectly natural phenomenon and as well worth observing as any other phase of nature, and is an evil which can be easily remedied from time to time by supplying more of the edible animals. Among the smaller forms to be sought for in fresh water pools and small, stagnant ponds are the various aquatic insects, especially immature forms, such as the "nymph" of dragon-flies and may-flies, the transformation of which may occasionally be observed. Another interesting group of aquatic larvæ are those of the caddis-fly, which live in self-constructed tubes made of twigs, pebbles, bits of leaf and other building material, and are found upon the bottom of nearly all ponds and sluggish brooks. Small fish of any sort are, of course, always applicable, provided there are not too many of them, and it must be borne in mind that fish are all more or less voracious and that smaller creatures, even of their own species, are never safe in their presence. During the spring of the year, the eggs of many amphibia, *i. e.*, those of frogs, toads, and a few species of salamander, may be placed in the aquarium, and their development within the transparent egg-envelope as well as their interesting larval growth and metamorphosis will prove of great interest.

In studying amphibian metamorphosis, toad eggs have a time advantage over those of frogs, since they pass through the larval or tadpole stages within a few weeks, the eggs being laid in April, and the fully formed, but very small, toads appearing by the last of July. Frog tadpoles develop in size alone during their first season, normally passing through their metamorphosis during the spring following their first, or, in the case of the bull-frog (*Rana catesbiana*), their second winter, but if these are collected in the fall and placed in an aquarium, the warm atmosphere of a room will cause them to change during the latter part of the winter, and by spring they will possess four well-developed legs and but a rudiment of a tail. The water-newt (*Diemyctylus*), one of the few wholly aquatic salamanders, is very common in small ponds and may be easily obtained, and in an aquarium in which an island has been constructed as described above, several partially aquatic salamanders will be able to live, especially if the stone which appears near the surface is coated with a sod of some marshy grass or a bit of bog-moss. Under such circumstances, also, it is possible to maintain one or two small turtles or a young alligator.

Among the larger invertebrates applicable to a fresh-water aquarium may be mentioned the various sorts of fresh-water mussels (*Anodonta and Unio*); pond snails (*Limnœa*), and the little fresh-water lobster, the cray-fish (*Cambarus*). These latter are found in abundance almost everywhere in the United States with the

exception of New England, and are very amusing as inhabitants of an aquarium, but are voracious and are apt to have unusually good success in catching fish, and thus ought not to be put into the same aquarium with valuable piscine material.

Some of the animals will require occasional feeding; either bread crumbs or the prepared "gold-fish food" being suitable for most fish, and small pieces of meat for the turtles, newts and alligators. Care must be taken in all cases not to allow pieces of food to remain long in the aquarium, and what is not eaten should be picked out in an hour or two, for all food, particularly meat, contaminates the water very quickly and will be apt in that case to kill the most of the animals. Cold-blooded animals do not eat often, and once a week is sufficient for most, and quite too often for some. Tadpoles, fish and crayfish are the most ready feeders, and will soon learn to come at once to the spot from which the food is distributed; but salamanders, turtles and especially alligators will not take food readily, and in order to induce them to eat, it is often necessary to hold a piece of fresh meat in front of the nose, or even in contact with their nostrils, for perhaps a full minute or even longer.

The most of the animals recommended may be collected by one's own exertion, or may be obtained at very reasonable rates by sending to Messrs. H. H. & C. S. Brimley, Raleigh, North Carolina. Alligators may be obtained through H. Fridenburg, Bienville Street, New Orleans, Louisiana. Many small fish and other forms may be supplied by local fishermen, especially by those who sell "live bait," and in cities some of the desired animals may be obtained at bird stores.

The above article has dealt almost exclusively with fresh-water aquaria, but any one who spends a little time within reach of the ocean may experiment with the keeping of marine forms. For this purpose some of the points given above may be directly useful and others suggestive, but in this, as in all cases involving the keeping of live animals, the methods must be adapted to the case in point, and this fundamental rule must be always observed: *Study the natural environment and then make the artificial one as near like it as possible.*

Window Gardens for City Schools.

By Fanny Julien, Instructor, New York City.

WHAT is your purpose in starting a window garden? Is it "to brighten the schoolroom," or did you chance to do so merely because a pupil presented you with a slip from an old geranium? The progressive teacher does not work by chance, she works by *plan*. Though she makes use of the straw that floats by her, she does not wait for it.

"School ornamentation" is a worthy motive, for by it the children are led into the love of the beautiful. M. Renan defines education as "respect for what is really good, noble and beautiful." But if your window garden is to teach your children this respect, it must be truly in itself an exponent of beauty, or you have failed in your object. A sunbeam that dances through a clean window-pane upon a vacant but well dusted shelf will give your class a sweeter nature-lesson, than that row of malaria-stricken plants imprisoned in pots of hardened earth. Their poor leaflets, like flags of distress, droop and beg for a few tear-drops of sympathy. A lesson in plant-suffering is not a profitable lesson in nature-work.

Certain schools have evinced a misdirected interest in nature study by crowding classrooms, which are already overcrowded with human beings, with a motley collection of nature specimens which are displayed on walls and on open shelves. A nature-specimen oppressed with a load of grime loses all trace of the divine touch that once gave it beauty.

In arranging her plan for a window garden, the teacher-gardener in the city schools must consider conditions that may well discourage even a professional.

1. Usually little or no sun.

2. Dry, hot air—the radiator sometimes opening into the very shelf which must be used to support the window garden.

3. Drafts of cold air, by reason of hasty ventilations of the room.

4. Want of space.

5. Daily accumulations of dust.

6. Inconvenience of water.

7. Great pressure for time on the part of both pupils and teacher.

8. Sudden fall in temperature, from the heat of crowded rooms during the day to the chill of the afternoon, when every part of the building is freely aired, and also when fires are let down, and during the frosty winter nights.

Brave heart may surmonnt all of these obstacles, but there is still a greater, namely:

9. The entire neglect which even a classroom Mascot would receive during the absence of the teacher every Saturday and Sun-

day. Our plans must bridge over two days of every week. What is the result? A plant has been carefully tended during five days, and we return to find it parched and wilted. It is revived by tender nursing, but, weakened by its privations, the coming Monday sees it bent on its stalk, blighted and frozen. Yet we can lay the blame of this upon no one's shoulders, since each has his hands full of his own duties under the present arrangement.

Then we attempt a water garden, and we spend time and effort until it becomes a glorious color lesson in vivid green. Now it is ready to carry on its beautiful little story of life, and the children are eagerly watching. For want of a moment's friendly touch in our absence, the story is broken, and the product of many days' patient thought is wasted.

The highest form of nature study is the study of life. Indeed, can you conceive of any nature study, whatever the subject, that is totally separated from all thought of life? In the lower grades of the schools we should have the living things present, and living things should never be neglected.

It is not the buildings, however beautiful, that form a university. The framework is but the casement that bounds its living force. Its life is its work, and its vigor of life is not found in the routine work contained within the letters of the law, but in the interests of its laboratories, born of the enthusiasm of the teachers. When it is deemed practicable to lift the guardianship of the public school building to a higher plane than the care of its floor, the plants instead of the enthusiasm of the teachers will be dampened.

Many instructors exist who are not hampered, perhaps, by any of the difficulties here enumerated, but I am writing for the devoted ones who are working against obstacles, and their name is legion. I suggest that these should arrange a transient rather than a permanent window-garden. This would certainly require forethought, but not necessarily expense nor increase of labor, since size need have no place in our calculations. Its success would depend on our application of the old principle which our acquaintance with the mind of a child leads us to apply to all our exercises, that a change brings new accessions of interest.

Whatever the character of our window-garden, there are certain general precautions which we should take against failure.

1. Watchfulness in regard to soil.

Plants are like people in some respects, for they work and they rest, and when they are sleeping they do not require food. They show their desire to rest by a stoppage of growth. Stimulants given at such times work as the goad to a tired horse, or, as wine, they excite to action when sleep is the remedy. Be ready to

feed the plant when it awakes, but give it just enough food to produce a vigorous growth. The month of January is considered an active season in growth for many plants. We may offer nutriment by supplying a richly fertilized soil, or a poorer soil in larger quantity. A small young plant that spreads itself in too large a space suffers harm just as other young people in like conditions do; and a strong plant that has been crowded against the wall until it has become root-bound, may be rendered helpless.

The secret of success in raising flowers is understanding the language of plants. A *Maranta* makes a very good schoolroom plant for the reason that it talks so loud that even the children can hear it. It cries pitifully for water, and when you give it a drink, it never forgets to say "thank you" at once. Even when it is sleeping, you can tell what it is dreaming about. Sometimes a plant tries, by putting forth smaller leaves, to tell that it is crowded or that it is starving, but people will not listen to it. Study your plants individually as you study your children, and you will find that they have characters and stomachs. Some can digest a rich food and flourish on it; while others will be greedy and suck up more than is good for them, get dyspepsia, and die from starvation after all.

Most plants dislike to be placed in strange surroundings. Acquaint yourself with the haunts and habits of the wild flower which is the progenitor of your cultivated one, and you will know in some degree how to settle your plant, for "blood will tell."

Soak a new flower-pot well before potting your plant, or it may absorb all the water which you intended that the roots should receive. Give your plant when thirsty enough water so that every little rootlet may drink and be happy. Yet the earth should never be permitted to become mud; therefore, to this end, consider both soil and drainage. Under watering is safer than over-watering, since with the second condition the roots rot and the earth sours; but with perfect drainage there is little danger of over-watering. A well-known and safe rule is to water the ground when the surface begs for it. The plant's earth-bed needs to be aired, and the air cannot enter when the pores are filled with water. Mother Nature knows this, and sets Jack Frost hard at work all winter long, crumbling up the ground by means of his little crystals.

3. Watchfulness in regard to cleanliness.

The leaves should be kept free from dust. The tinkle of the rain-drops, as they fall from leaf to leaf, is music to the tree. Certain sprays of Ivy which have a happy home in the library of the Society of Pedagogy, owe the health which they keep throughout the winter to the weekly immersions which they receive. The fresh-water bath is an excellent means of banishing the red spider,

which flourishes in dry, warm air. To counteract the radiator-dried air of the classroom, pack your flower-pots in sand or moss, and keep this constantly wet.

There are a few cannibals among plants, such as the *Sundew*, which court the company of insects, but the majority of plants do not enjoy the association. To get rid of the Aphis and the Scale, use water containing fir-tree oil soap [which does not hurt the plants], or else Nicotine. A stiff brush is necessary for the removal of Scale.

So many lists of suitable flowering-plants have been given in the various journals, that it seems superfluous here to enumerate them. Many plants will bloom with ordinary care and a little sun or even with strong light, and a succession may be arranged at trifling expense.

There are a number of beautiful trailing plants which can be used for a window garden, but they need plenty of water and root-room and rich soil. *Saxifraga carmentosa* well repays the cultivator. The *Tradescantias* are tenacious of life, and *Nepeta* is hardy. *Moneywort* and *Kennilworth Ivy* will grow readily from seed.

It may be that the teacher gardener is inclined to take water instead of earth for her medium of cultivation. Many vines will root readily in water, if strong slips are selected in the fall; certainly *German Ivy*, *Madeira Vine*, *Nasturtiums* and *Tradescantia repens* and *Aquatica*. *Morning glories* will bloom quite freely around a window.

A charming window garden of a transient character, and which will keep pace with the seasons, may be formed of the wild flowers, if the teacher occasionally visits the city's suburbs. For this purpose many of the hardy kinds, such as Marsh Rosemary, with its lavender flowers, and the glowing *Salicornia* or Marsh Coral of the autumn, and in the spring blue violets and golden dandelions and Marsh Marigolds can be taken up in their own clumps of earth, and brought into the schoolroom in paper pots. Cut sprays of taller plants will last a long time. The late goldenrod of the beach is coarser than the inland species, but a certain little English artist that saw it for the first time last fall would tell you what a wonderful color-study it makes, especially if you can coax some butterflies to keep it company.

Use twigs of winter, that show the leaf buds tucked under warm, woolly fuzz, and branches of evergreens and of the bright-berried shrubs and vines. In the springtime we will of course take twigs of pussy-willow and alder and the fruit trees. Later in the season sprays of the wild rose, selected for their closed buds, will, with a few grasses, turn your garden-shelf into a fairy bower

that will last for days. The fragrant leaves of the bayberry make far more efficacious "good tickets" for the children than those we are using. There is no limit to what Mother Nature will give you for the asking, if you will seek her in her haunts, and I refer you, for the better understanding of her stores, to the article on "The Wild Flowers of New York City," published in the present MONOGRAPH. Plan wisely, however, and keep your profusion from turning into your confusion.

In the early part of this article I spoke of accretions of interest that the efforts of the teacher might gain for her window garden by giving it a transient character. Does this thought satisfy you? Can any plan of "school ornamentation" minister to the growth of the child without bringing into play his active cooperation? Yes and no. I believe that beauty in itself exercises an influence that will echo to eternity. Stand alone amid the hush of the deep, pine woods, and and though you stir neither hand nor foot, your heart will voice its holy silence. There is danger of depending on human work and agency. Our very anxiety to force a response from the children frequently smothers it.

But while we should not search too closely for evidence of active interest in the child, we should spare no effort to promote it, and to this end let the child share the teacher's labors, whether in the collection of plants or in their charge. If you would realize how the care of a simple weed (where other interests are lacking) is able to transform indifference into an absorbing passion, read "Picciola," by Saintine.

I should like to mention two kinds of window gardens which seem specially adapted to the needs of city schools, The teachers who prefer using cultivated plants will find one formed of bulbs very satisfectory. To those who prefer working in a more rustic fashion, I suggest a fernery or a terrarium.

Bulbs have about every recommendation, that is, if a reserve stock is kept. They are inexpensive, easy of culture, of varying form and color, and can be made successive in bloom. They have also a primary qualification for a school window garden in that they are connected with story and history. Insects do not trouble them, they need little sun, and when in bloom they do not suffer from a fall of temperature at night. They can also do without Saturday and Sunday attention, as saucers of water may be placed underneath the pots. They may be grown in water or in earth, and if the children join in their care, by using both media the whole process of growth can be watched.

The bulbs should be potted in October. Look well to the drainage. Put in the bottom of the pot an inch of pebbles, and

charcoal to keep the roots sweet, then pack a layer of moss and above this the earth. The soil may consist of sand, loam and well-rotted manure. Some people have used successfully ordinary ground with well-rotted bonedust as a fertilizer and in place of the sand; but in such case settle the bulb upon sand. Water well, and place them for a couple of months in a cold, dark cellar in order that roots may grow, for the health of the bulb largely depends upon the strength of these roots. The reasons that bulbs are kept so long a time in the dark and coolness is that it would exhaust their strength to form roots and leaves at the same time. Let the children give them a very little water once in a while. This will keep them interested in the development.

Plant the hyacinths so that the crown is a little above the surface, but tulips and narcissus about an inch below. Snowdrops, crocuses and freesias are much smaller bulbs. Freesias are very fragrant and will bloom at Christmas, if it can be kept from freezing. The Easter lily should be planted in a very deep pot, because roots grow out above the bulb, as the stem lengthens. A very good plan is to fill up the pot with earth, as the stem grows, so that the lily may be well anchored. The amaryllis is a bulb quite easy of culture, if you will allow it to sleep through the autumn, and will remember that from time to time it likes to take short naps. It will give a crop of large lily-like flowers. The dry bulb, when ready for the awakening, may be repotted in rich leaf mold and sandy loam, and like other bulbs should be gradually brought to the light and heat and abundance of water. Bring the bulbs to your window garden at intervals of about three weeks and you will secure a succession of bloom.

If you like you may vary the form of your bulb garden by using them as a centrepiece, sinking the pots into a box of earth, around the edge of which has been planted in September the vines already mentioned.

An inexpensive bulb for water culture is the Chinese lily. This should be settled firmly by means of pebbles in a bowl of good size, using charcoal to keep the water sweet. It affords an interesting root study, and in about six weeks it will bear fragrant white flowers. Another lovely water plant with mossy foliage is called Parrot's Feather.

The terrarium and the fernery can be combined without difficulty, and by their united attractions contribute more largely to the interests of the schoolroom. The only necessary apparatus is a wooden box or frame with sides of common window glass, and a deep zinc tray with a perforation in the bottom for egress of surplus water. A large opening in the front may be contrived by

letting two half panes of glass slide upon one another. Slope must be considered, so that the water that is not required may run to its proper outlet, and arrangement should be made for a constant current of ventilation, however slight. This kind of window garden also has the advantage of only needing occasional attention and overhauling.

A trip or two to the fields will supply its autumn needs. Find old bark and stones that bristle with tiny red-tipped horns belonging to Little Boy Blue; plumes of grasses, dwarfed maple trees, germinating acorns that the white oak has thrown down, a lowly belated dandelion, happy, common little weeds with pendant purses full of money; clover leaves that fold their little hands when they go to sleep, "just as little children do;" clumps of moist, rich earth, that will open for you what you wish; the very roadsides are full of treasures.

Drowsy spinners will be glad to crawl into such a home to weave their silken hammocks; little black musicians will merrily tune up their tiny fiddles, so that city children may hear them play.

And then in winter, when these are all asleep, what a picture of the woods it presents, with its rocks and soft, velvety moss! The tender baby ferns curled up in their furry blankets, close to the foot of Mother Fern, peep out of their earth-bed, and appeal at once to the heart of every child of nature.

When you are ready to plant your ferns put a layer of sphagnum moss over the stones at the bottom of your fernery, in order to prevent the ground from filling up the cracks. Use leaf mold and plenty of fibrous roots and rocks, and study the ferns in their native haunts, so that you may be able to imitate nature's arrangement.

A friend makes the suggestion that a "vegetable annex" to the ornamental window garden might be made a success, especially as such plants could be placed almost entirely in the children's charge. Prosaic as they seem, the food plants are linked with song and with history. The lovely feathery fennel is quite hardy, and parsley is a jolly little plant that was invariably used by the ancient Greeks and Romans in the making of their festive garlands. The curl in its tresses has been produced by cultivation.

The carrot is an honest little Dutchman that came to England during the reign of Good Queen Bess. It is said to disown its meddlesome cousin of the fields. The fern-like effects in its foliage possibly point back to a more pretentious period in its life-history, when, in ancient Greece, it flourished under the name of Daucus.

For a bold color study, we may plant the beet, a patriarch among vegetables, for it has been eaten over two thousand years,

and is a native of the land of the pyramids. Any plant furnishing sugar will surely be dear to the heart of a child! The Chilian beet is now used in ornamental gardening for large ribbon borders.

Sweet potatoes make a foundation for lovely vines, and the fact that they were in use four hundred years ago among the Indians of Brazil should be of interest to American boys and girls.

For rush effects and also for the sake of their unique fragrance, try leeks and chives. The latter is accustomed to hardships, as it is a native of Siberia. The place of the Chinese sacred lily may well be taken by an onion bulb, as it grows easily in water. An ornamental species, *Allium Moly*, bears golden yellow flowers and is hardy. Herodotus [450 B. C.] stated that an inscription then on the Great Pyramid recorded that 1600 talents' worth of onions, radishes and garlic were consumed by the workmen during its erection.

The grasses may find a purely American representative in the corn grain, as corn was cultivated by the Indians before the advent of the Europeans. Do you recall the beautiful description in "Lorna Doone" of the Thanksgiving in the harvest field? You may read it to the youngest children, as also the husking frolic in "Hiawatha" of the Indian boys and girls at the expense of Kahgahkee, the corn thief.

As for the bean, is it not still the refuge of the teacher for the seed-develvopment study? Patiently, back and forth, from home to school, the children will carry their little bottles of water, watching the seeds as they swell with joy and burst from their seclusion, and vie in development of root and leaflet! In this water-culture we have the individual care-taking which should not tax very little children for too long a time, followed by the unifying of their private interests and ambitions in one great Social Bean, planted by the class in earth. This, in a few weeks, will display its beautiful scarlet blossoms and its useful food-pods at the same time.

Of course, this is an old, old story for you—but remember that it is new for the children, and they never heard a better story, for it is perfect from beginning to end. Not every plant anchors itself in truth, and yet climbs into the mists of fairyland. The bean has an important place in history. The Egyptians so reverenced it that their priests refrained from even looking upon it. Pythagoras taught that it possessed a soul, which, like the human soul, according to the ancient belief, was subject to the laws of transmigration. Beans were anciently used as means of voting on public matters, the white bean signifying yea, and the black bean a negative.

If, however, I cannot persuade you to use the bean for class-

work, ask Cinderella's godmother for a seed from her pumpkin. Three hundred years ago pumpkins were made into pies by cutting a hole in the side, taking out seeds and fibres, then stuffing the pumpkin with apples and spices, and baking the whole.

Permit me to summarize my article by saying that a school window garden, of whatever nature, should show three traits:

1. It should enfold a thought.

We need not worry too much over our method. Our thought in nature work may bring the children toward some plant; or the plant may lead them to the thought; but it will not be for the sake of its pink and white beauty that we will select our plant, but because it is illumined.

2. Let your window garden be successful.

How? First, by your making a wise plan that will lead to progress. If your plan fails,

"And the best laid plans of mice and men gang aft aglee,"

still be successful. Turn your luck and make coin out of your failure.

After all your care, did your fernery mold? Very well, make it mold more, and study the mold. Get a little hay from the nearest stable, close it up tightly over night, and in the morning you will find that the fairies have visited your moldy garden and left behind them the tiniest, most beautiful parasols, made of pure white lace, so delicate that a breath might wither them.

That is nature's way of turning deformity into beauty. That is nature's way of changing death into life.

Did you find your mignonette, that you tended so faithfully, covered with the aphis? Never mind. Study the aphis. Remember that your window garden is not only a window garden, it is also a zoo. To be sure, your aphis belongs to the animal kingdom, but he has associations with the vegetable kingdom, and even with the mineral kingdom. He is a very interesting little fellow, unwelcome as he is. The aphis is the friend of the ant, and the ant is one of the greatest earth and mound builders in the world.

The moment that you draw, in your nature-teaching, inflexible lines between the plant and the animal and the mineral, that moment you may know that you have failed in teaching nature-truth. The plant sucks life from the mineral, it offers its substance to the animal, yet it borrows from its debtor. Both plant and animal crumble to dust, yet both return to the Sun that gave them birth.

Plant Physiology in the Public Schools.

By Marie L. Sanial, Instructor, Training School for Teachers, New York.

WE will briefly consider the guiding principles upon which nature study—and consequently that part of it which relates to plant physiology—should be conducted.

There are two great facts which the writer deems of fundamental import and to the value of which she has previously called attention. As their true meaning is becoming more generally recognized and it is now apparent that there is a tendency to act upon the practical suggestions which they contain, it may not be amiss to state them here again, although space and time are wanting for a thorough treatment of the subject.*

One is the effect of visible motion upon the perceptive faculties. If this striking fact be taken into account, the general order in which natural objects should be presented to the child is at once determined; the animal evidently coming first, while in the vegetable world, which comes next—and, for obvious reasons, not far behind—those plants must be selected which, by their bright colors, rapid growth, perceptible movements, or other visible activities, are best fitted to command the child's attention.

The second fact, closely related to the first, is the child's natural process of observation; a process necessarily analytical, yet characterized by a strong aversion to abstraction of any sort. For instance, while examining any given part of some natural object, he will not dissociate it in his mind from the whole to which it belongs. He will not conceive it as having what it has not, namely, a separate existence. He must first see the whole as such, and the interest which he subsequently feels in the part is only a part of the interest which he feels in the whole.

As this question of abstraction cannot be considered here at length, we must request our readers to take for granted the whole fact as above stated. Of course no doubt is entertained that the child's mind is naturally possessed of analytical powers at a very early stage of its development. It must evidently be so, since observations, implying analysis to a more or less extent according to its own intensity, must precede the exercise of the synthetic or constructive faculty, which is largely imitative.

It falls under the sense that these powers should be neither unduly restrained nor in the least overtaxed; but that they should be trained, painlessly and even pleasurably, by supplying them with such attractive materials as we know the child would of himself select for the purpose of observation.

*See New York Teachers' Monographs, June, 1898. Report of the Convention of New York State Teachers' Association, Rochester, N. Y., 1898. Report of the New York Vacation Schools, 1899. Bulletin of the Torrey Botanical Club, 1899.

Manifestly, these materials are no other than those which have already proved most attractive to the child and therefore most effective in awakening his perceptions. The order suggested by the power of visible motion upon the perceptive faculties [which is our first great fact], will therefore be followed but enlarged in the child's natural process of observation [which is our second greatfact].

The highest forms of life, and in particular the animals which having undergone the process of domestication, associated to man by bonds of mutual dependence or benefit, will first be observed in the distinct but cooperating and inseparable activities which the various parts of their body, their various "organs," respectively display. Thus, by the way, will at the same time be imparted, easily and attractively, an amount of anatomical and morphological knowledge which, ever so rudimentary, would otherwise be difficult of acquirement and repelling by its dryness; that is, "scientific," according to the old method of teaching.

When the plant world is reached the same mode of investigation—which we might now term the "physiological mode," imposes itself with still greater force, because of the less visible functions and activities in the vegetable than in the animal organs. The "life aspect" must be kept in view at every step, and care be taken to always show "the plant in action."

For this purpose it is first of all necessary that the teacher should have in the classroom germinating seeds and growing plants, selected in special reference to their visible display of organic motion; such, for instance, as among seeds, peas, pumpkin or squash, morning glory, corn, oats, arrow arums, castor oil, peanuts and dates—and among growing plants, geraniums, oxalis, sensitive peas, clovers, dandelions Jacks-in-the-pulpit, hepaticas, spring beauties, hyacinths, freesias, wild violets, wild daisies, grass.

It is hardly necessary to dwell here upon the moral effect immediately resulting from the cheerful appearance given by the sight of plants to a classroom otherwise chiefly suggestive of stern discipline and dreary work. The teachers in schools of popular cities, and particularly of those quarters where the poor must ever reside, entirely divorced from nature, fully understand that. To make the children love the school is an easy task; it should be the first duty. They should also be encouraged to cultivate some plants at home, which they should be asked to draw and to describe. At certain times all should be required to bring for comparisons and interchange of observations the results of their window gardening.

In the classroom the position of some of the plants in regard to light or heat should be so changed, occasionally, as to quicken, retard or even temporarily suspend their movements; the result

being made still more apparent by comparison with those of the same kind that have been left unmoved.

The various bendings, curvatures and other movements performed by growing roots are among the most remarkable vital phenomena of plants, and the children should be given ample opportunity to observe them by the use of glass jars instead of earthen pots, by the substitution of water for soil, and by other devices equally simple. This, indeed, is the more important, as under ordinary conditions the roots are not observable. While most of the children of school age know of their existence, such ideas of their function and behavior as they may have formed, if they have in some way been led to form any, is at best extremely vague. Of even so little as their anchoring function, which is most obvious, few know anything. The dark, tortuous, rigid, serpent-like, uninviting aspect of those which they may have seen exposed is certainly not calculated to arouse their sympathetic interest. That there is not only life but extraordinary motion in roots, an immense power ceaselessly exercised under ground against numberless obstacles, difficulties and enemies for the benefit of the beautiful thing that rises above in the splendor of light, must surely be to the child one of those mind and soul-stirring revelations that deeply affect his moral as well as his intellectual perceptions.

With the emergence of the tender stem from the dark regions where the grimy root, miner like, performs its hard work, we have a beginning of visible plant life. This is one of the wonders of spring, and the child will watch it intently.

That stems are blind no child will deny. For this very reason their sensitiveness to light is an inexhaustible source of wonderment. It can be illustrated in many simple ways, some of which, although generally well known, may still profitably be mentioned here. For instance, spread some mustard seed, radish seed, oats or flax seed, previously soaked, on a moist sponge or on some moist sawdust or cotton and keep it a little away from the window. The stems will grow toward the light until they touch the window-pane. Again, turn a geranium over on its side so that the plant shall point horizontally into the room; the stem will soon be seen bending upwards as it grows, struggling as it were with its own shadow, and finally curving towards the light.

A rapid development of stems may easily be produced in the classroom by placing twigs in jars of water kept in a bright, warm window. A piece of charcoal in the water will keep it pure, and, as it evaporates, fresh water (not chilled) should be poured in. Some of the best twigs for this purpose are those of the horse chestnut, tulip-tree, beech, poplar, cherry and apple.

In the stems of climbing plants we have examples, not only of quick growth, but of rapid motion, so remarkable that the teacher should not fail to use them. In warm weather the French bean (*Phaseolus vulgaris*) makes a complete revolution in one hour and fifty-seven minutes, the morning glory (*Ipomœa*) in one hour and forty-two minutes Since these revolutions are performed by fairly long portions of the shoot, they may, like those of a clock hand, be seen with the naked eye, especially when a collar of white paper is placed on the shoot in the sunlight below the overarched portion. The shadow of the moving part, like the clock hand on the dial plate, is then seen slowly but plainly advancing over the surface of the paper.

In a number of twining plants neither the light nor the external condition has any influence upon the "direction" of the twisting movement. For instance, the twining *Polygonum* turns "to the right" (that is, from the west, through the south towards the east), whereas other plants, as the scarlet-runner bean and the *Convolvulus*, turn "to the left" (that is, from the west, through the north towards the east). The plant cannot be coerced into any other path, even if the twining portion be continuously bound in an opposite direction. There are a number of moral lessons to educators as well as to pupils in this and other physiological facts.

Especially interesting is the observation of those stems that climb up into the sunlight by means of special organs, known as tendrils, which are very sensitive. While the stem, swayed by the wind, grows in the direction of a support, the thread-like tendril, tightly stretched, stands ready to grasp it. As soon as the contact occurs the support is firmly gripped by the tip of the tendril, and the tendril itself begins to contract spirally. In plants of the passion flower the curvature visibly commences thirty seconds after contact. The period of revolution taken by the nutating tendrils of *Cobœa scandens* is only twenty-five minutes.

Stems of climbers that run up steep rocks or large trees are provided with "light-avoiding tendrils," so named because they seek, as they must of necessity, a support through which no light can come. The tips of these tendrils vary in structure and *modus operandi*. In some plants that climb up steep, smooth walls they are provided with tiny knobs or discs that spread out like the toes of a tree-toad and secrete a sticky fluid which hardens and cements them to the most polished background. An illustration of this is the Japanese ivy (*Ampelopsis veitchii*), frequently known as Boston ivy.

The vines of the passion flower, *Cobœa* and Japanese ivy all flourish in the school environment and are, moreover, readily obtainable.

From the Stem issues the Leaf.

There is no end to the possible use of leaves in the classroom. Their value in the manual training department of study cannot be overestimated. To the infinite variety and matchless elegance of their forms and arrangements man is largely indebted for his artistic achievements; and as art in all its branches is a reflex of human conditions, human thought and human progress, it may justly—and without the least exaggeration—be claimed for the leaf that it is entitled to a prominent place on the frontispiece of human history.

But to learn from the leaf all which it may be made to teach requires a closer acquaintance with it than can be gained from the superficial look usually bestowed upon it. To the shallow observer a leaf appears simple enough and actually magnificent. Respect for it begins, however, with the first perception of its important function as the purveyor of aliments prepared by itself for the vegetable world, even leaving aside its immense work in other directions.

Here, again, as in the case of the stem and all other plant organs, the visible activities of the leaf must at the outset be shown to the child in order to awaken in him sufficient interest for further observation. This may readily be done. We need not go to the tropical India, where " the small disturbances of the air produced by the approach of man are sufficient to cause the pinnate leaflets of *Oxalis sensitiva* to fall together rapidly." Wherever brick and asphalt have not monopolized the soil, there are plants growing, which, though less bashful before the lord of creation, give ample evidence of their sensitiveness. For instance, the common white clover, the oxalis, both wild and cultivated, exhibit the phenomena known familiarly as "the sleep of plants," the night position of the leaves differing materially from the position assumed in the full light of day. By artificially changing the conditions of illumination, these changes of position may be brought about during the school session. The motility of the leaves of the wild sensitive pea is well known to all who have plucked one of the graceful, fern-like leaves and seen the immediate closing of the leaflets. The plant is an excellent one for classroom growth, flourishing as it does in places subjected to drought and requiring a poor sandy soil. By withholding water, the leaflets may be made to demonstrate the method by which their surface exposure is reduced, the leaf itself even sometimes bending against the stem, after all the leaflets have folded.

On the Relation of Domestic to Wild Animals.

By Elmira Lodor, Instructor, Philadelphia.

"ALL our knowledge being derived from experience, we can only judge of things as they have been, by things as they are; and as every animal is now the product of a parent organism more or less like it, so the natural inference in regard to any antecedent animal is that it also was the product of a parent organism more or less like it" (St. George Mivart). With this idea of the gradual developing of one type into another for an hypothesis, the problem of the relationship existing between domestic and wild animals resolves itself into an inquiry as to how the present forms have arisen from the ancestral types. What has given rise to the differences which exist between the animal in the wild state and in the state of domestication?

The answer to the question must be found in an inherent quality which all life seems to possess; mainly, a tendency to respond by physical alterations to change in environment and the capability of transmitting those alterations to succeeding generations. That is to say, the solution of the question is a part of the larger one of heredity and variation.

To attempt to solve the origin of variation, or even to touch upon the mystery of heredity, would be beyond the scope of the present paper. It will suffice to assume the existence of the fact that, given a change in circumstance, whether that be a purely internal stimulus, a climatic alteration or the somewhat more complex one of food-supply, a change will take place more or less gradually in the animal type so affected. Nor will this change be restricted to the organ or organs directly involved in the particular stimulation. On the contrary, because of the law of correlation of variation, it becomes impossible to alter in the least degree any organ in any part of the body without causing a corresponding change in remote parts of the body. Hence, out of what may seem a comparatively slight change in the life conditions of a given animal there may ensue alterations of sufficient degree to constitute the beginnings of a new species. A case in point is found in the Ancon, sheep. This variety arose suddenly in 1791, as the chance sport of a single lamb. The offspring were either Ancons or ordinary sheep, but by separating those which possessed the long body and short, bandy legs of the first Ancon, in time a distinct variety came into existence. A second illustration is the one recorded of the rabbits of Porto Santo. A litter of rabbits of the ordinary variety was introduced into the island in the fifteenth century. In a short time the rabbits responded to the totally different life conditions

under which they were placed by pronounced physical changes, becoming of a uniform red-brown tint on the dorsal surface, smaller in size, hardier in constitution and fiercer in habit. Indeed these changes have been so marked that at the present time the Porto Santo rabbit will no longer breed with the variety from which it was originally produced.

These are but two illustrations chosen from a multitude of similar instances, which all go to prove that new species have arisen out of this process of natural selection, which in turn has for its foundation at least the two factors of variation and heredity. If in the wild state the formation of new species is governed by these laws, the development of the domestic animal must have been brought about by man's adaptation of the same fundamental forces. In fact, it has been by seizing the least variation which will serve his purpose of greater use or increased market value that man has created the innumerable varieties of the domestic animal. It is an impossibility to generate the original variation by artificial means, but given the initial impulse, whatever it may be, and man is able, by the careful selection of those individuals in which the alteration is most perfect, to mould almost at will a new species.

There are abundant proofs in the oldest written history, indeed, in the geologic records of prehistoric time, that man has made use of these fundamental principles in the domestication of animals almost from the time of his own appearance on the globe. When this fact of the centuries of domestication is taken into consideration, there is small room for wonder that the origin of many, if not of all, of the domestic animals of to-day is shrouded in mystery; is, in fact, rather a matter for conjecture than one capable of actual proof.

It is to the Neolithic period that we must turn for the earliest record of any domestic animal. In the lake dwellings of Switzerland and in the Danish middens are found the bones of a canine animal more closely resembling those of the dog than those of any wild member of the Canidæ. Therefore to that remote period we must trace "the most singular and the most useful conquest ever made by man" (Cuvier). The most superficial examination of the various members of the Canidæ suggest at once the thought that the dog of to-day, in spite of the many breeds, must be the descendant of the wolf or jackal. This hypothesis is borne out by the fact that the domestic dog (*Canis familiaris Linn.*) breeds freely with the coyote (*Canis latrans Say*) and various other wolves, the result being fertile offspring. But whether the dog has arisen from one species of the wolf or jackal, or whether it has been derived from several species still remains an open question. The most ancient historic records,

those of Egypt, dating back at least five thousand years, contain accounts, and in some cases pictorial representations, of at least seven breeds of dogs. These do not closely resemble one another, but distinctly resemble those which exist at present. In the time of the Greeks and the Romans the number of breeds had increased to fourteen. When we add to this historic evidence the fact that the dogs of various regions of the earth more closely resemble the wolves or jackals of the same region than they do one another, the natural conclusion seems to be that the origin of the dog has been a multiple one rather than a selection of one type. The Esquimau dogs very evidently resemble the gray wolves (*Canis lupus Linn.*) of the Arctic region, and are frequently crossed with the wolves to give greater endurance and ferocity to the progeny. The Hare Indian dog is evidently a descendant of the coyote of that region, while the Pariah dogs of the East are probably the offspring of the Asiatic jackal. A further proof of the the intimate connection between the wild and domestic type is found in the comparative ease with which it is possible to tame wild members of the Canidæ. This has been done frequently in the case of the North American wolves, and there are several cases on record of the taming of the Australian Dingo. Since the dog is evidently domesticated with comparative ease, and since he must have been of the greatest service in the hunting ventures of prehistoric man, it seems more than probable that various independent attempts to subjugate the wild jackals or wolveswere made in different regions. Therefore, it seems a probability at least that the progenitor of the dog is not to be found in one variety of wolf or jackal but in several.

To the same geologic period that the bones of the dog belong are found also the remains of the horse. The bones are abundant and suggest that the time of primitive man may have been spent in hunting these animals. Since they were so abundant, possibly they were partly domesticated at that time, though there is no direct evidence to prove it. At the present time no truly wild horse exists, but from the numerous horses which have a dun color and striped shoulders and legs, it has been suggested that this marking may have been a reversion to the ancestral type. Consequently an ideal wild horse of the Neolithic period may be imagined, smaller in size than the horse of to-day, with a shaggy dun-colored coat, with darker stripes on the shoulders and legs. Be that as it may, so far as skeletal structure is concerned, the family tree of the horse has been traced back in an unbroken line to the little Eocene Ungulate, Eohippus, no larger than a fox, with four well-developed toes on its front feet and three on its hind feet.

Through the labors of Huxley, Marsh, Leidy, and many others, the beautifully perfect line of development has been followed through its slow gradations up to the form Equus caballus Linn., the horse of to day. But the horse, like the dog, had been domesticated before the dawn of history, so that we do not know which particular variety of horse gave rise to the many varieties of modern time. It has been suggested that the present horse is derived from an Asiatic stock through Greece and Italy. That may account for some varieties, but from a passage in Cæsar it has been argued that a horse indigenous to Great Britain had been domesticated before the time of the Roman conquest. Then, too, the North American Indians, when they first came to the knowledge of the white man, certainly possessed tame horses. Is it not probable that, given a race of men and the easily tamed horse in the same region, the result would be the domestication of the horse of that particular region? Then the origin of the horse, like that of the dog, is probably not to be found in one time, place or variety, but in many.

Cattle seem to have been among the first of domesticated animals. They appear in the earliest records of the Hindoo, of the Hebrew and of the Egyptian peoples. They formed a medium of commercial exchange between primitive races, and still do, to some extent, in Southern Africa. But geological investigation proves the yet earlier domestication of the ox, and has discovered three prehistoric varieties from which many of the present European breeds have been derived. Bos longifrons, the most common of these three forms, is found in the lake dwellings of Switzerland and is said to be the progenitor of many of the present Swiss breeds of cattle. From Bos frontosus nilsson, somewhat larger than Bos longifrons, with which it co-existed in certain regions of Scandinavia, are derived the cattle of the Norwegian mountains. The same or similar form has been found in the Irish cranioges, and to this form have been traced some of the existing Irish cattle. The remaining form, Bos primigenius Bojanus, the ur of the Niebelungen myths, was almost as common as Bos longifrons; and from it have descended many of the English and Continental forms of to-day. Other fossil forms have been found in the European tertiary deposits which are undoubtedly the ancestors of still other modern breeds.

As a final illustration, out of the many other domestic animals, I have chosen the common cat (*Felis domestica*). Of all the Felidæ the common house cat is the only domesticated member at present. Attempts have been made at various times, in various countries, to domesticate other members of this family, but the attempts have

been futile. The Felidæ are not easily tamed, and, because of their nocturnal habits, it has been impossible for man, even in the case of the cat, to govern to any great extent the development of species. As a consequence, the differences existing between the different kinds of cats are not so marked as those existing between the different breeds of dogs. The differences which do exist are mainly those of color and the length or quality of the fur.

The domestic cat seems to have closer affiliations with the wild cat (*Feliscatus*) than with any other member of the Felidæ, though the whole family forms a remarkably "natural" group. In countries where the domestic cat is allowed to run at liberty it crosses freely with the wild cat nature to the region. Their offspring generally show their origin by retaining the "tabby" markings of the wild cat.

The earliest known records of the cat in a state of domestication are found in Egypt, "which, as the granary of the ancient world, might well have been the country in which the animal was originally tamed." Of Egyptian origin, also, and dating back to the eighteenth or nineteenth dynasty, is the oldest pictorial representation, which is a drawing of a cat seated under a chair. The mummied bodies of three varieties of cats are found in Egypt, two of which persist to the present day, either wild or in a state of domestication. From Egypt it must have been introduced into Greece. From Greece the next step would be to Rome, and thus finally to all Europe.

Some Hints on Nature Study as Taught from the Evolutionary Standpoint.

By George William Hunter, Jr., Instructor, New York City.

I HAVE been asked to point out one or two simple types of animal life that can be kept and watched in their process of development in the schoolroom—types that will serve as texts for the doctrine of evolution.

No doubt the oft-referred-to examples of the metamorphosis of certain of the common insects, or the development of the frog from the tadpole, are the most desirable types, both on account of the ease with which the material can be obtained, the familiarity of the child with the material, and its general adaptability to the work in hand. I will now try to indicate in a purely tentative way how such types can be used to the best advantage in the schoolroom.

The interest in nature the child has; we have only to direct this interest and his predatory instincts into the right channels and we will soon have all the materials with which to work at our command. Insects of all kinds—flies, grasshoppers, moths and butterflies—and the larval stages of all these forms will soon find their way to the schoolroom, if certain points in their life-history be told and the children interested. For example, the life-history of the Vaporer or Tussock moth (*Notolophus leucostigma*) may be cited. The caterpillar of this pest is harmful to many of our shade trees. It is familiar to most of our New York boys; a pretty creature, about an inch in length, with a coral-red head and yellow body, bearing tufts or brushes of black hair on the dorsal side, and two longer pencils of hair at the anterior end just back of the head. The caterpillar appears usually in midsummer, eating and destroying the leaves of many of our choicest shade trees. Last summer it appeared in such quantities in the upper part of our city as to be absolutely a pest. Cocoons of dirty white silk and hair are spun in every crevice and cranny of walls and fences and under projecting branches of twigs of trees. The moths when hatched are of a dirty white color, and, as is well known, the female is wingless. The eggs are laid in a dense mass on the old cocoon of the female, and are protected by a mass of white, frothy substance formed by the female. This substance soon hardens on exposure to the air. A certain practical value is attached to the collecting of such a form as a check on the destruction of our shade trees. A certain teacher in one of our city schools recently stated that, by means of the children in her classes, many thousands of the egg-masses were destroyed; and in many of the schools of our up-State neighbors

this same method of protecting our shade trees is made use of with even greater success. Many other of our injurious insects might be cited. For description of these I might refer teachers to the bulletins of the State Entomologist, or those of the United States Department of Agriculture, Division of Entomology, all to be had for the asking, and to Scudder's "Frail Children of the Air," and "The Life of a Butterfly," or Holland's "Butterfly Book."

For the study of insects in the schoolroom a breeding cage or live box should be constructed out of a medium-sized wooden box, the cover and one side of which is removed, and mosquito netting tacked over the opening thus made. In this box may be placed a pan of moist earth and some of the growing or freshly cut plants upon which that particular animal feeds. By means of these boxes the life of the caterpillars may be watched, their gregarious or solitary habit made out, their method of feeding, kind of food, relative amount of moisture they require, and many other problems of environment studied. Later the pupation of the caterpillar may be observed, and what is there more interesting to watch than the building with such infinite care of that little resting place—the cocoon? After the cocoons have been made they may be removed and hung in some warm but not too dry place, there to wait the bursting out of the imago on some warm sunshiny day in the spring.

The large, easily-found cocoons of the *cecropia* or *polyphemus*, our largest moths, make excellent classroom demonstrations of the process of emergence from the cocoon into the adult state. A series of these large cocoons may be opened, and the gradual change of the pupa noted, the process being elucidated by means of figures placed upon the board. These moths, the electric light moths of our small boy, belong to the Bombex family, the family to which the silkworm belongs. Hence the cocoons will show the coarse silk, and offer a text for the economic importance of the silkworm. To this same family of the Bombycidæ belong the tent-caterpillars, the gregarious creatures whose silken tents can be seen in our common fruit trees. One of their homes, gathered into a breeding cage, will amply repay close study, and afford a class of children much profit and interest. Many new points concerning the community life of insects can be learned in some such manner as this.

But the growth or evolution of animals, as shown in their processes of metamorphosis, need not be confined to the insects. In the spring the egg-laying season of the amphibia occurs and we have material free for the taking in any small pond near the city. Crotona Park, Van Courtland Park, and Fort Lee offer collecting grounds that always repay the trip. Frogs' or toads' eggs, the latter distinguishable by the fact that they are laid in strings,

instead of masses of gelatinous material, can be collected in their early stages almost any warm day in March or April. Leave the eggs in a shallow pan in the schoolroom window, with just enough water to cover them, and allow the children to examine them from day to day. If expedient, place upon the board an outline sketch showing the egg enlarged. Have the children copy this. As the development advances, make successive outline figures showing the gradual overgrowth of the food-mass of the egg by the embryo, and the ultimate hatching of the tadpole with the foodyoke distending the abdomen. Certain of the children might be allowed to make individual observations on the daily growth. The subjects of foods, environment, protective coloration and the like could be taken up and discussed on different days. Some live adult frogs or toads could be profitably used in the aquarium. The leopard-frog, wood-frog, or green-frog can easily be obtained in any of the fresh-water ponds of the vicinity and used for this purpose. The children will be only too glad to donate material, and an aquarium is an easy matter to keep after once starting it. A well "balanced" aquarium, with its living inhabitants, its pebbly bottom, and such waterplants as Elodea, Utricularia, Nitella, Spirogyra and Lemna—all of these easily obtainable in Van Courtland pond—affords not only a bright spot in the schoolroom, but many a practical lesson in natural history. Aquatic insects should be reared in a separate aquarium when it is practicable. The child who has seen the fairy egg-raft of the mosquito and its actively wriggling larva will then understand the practicality of oil as an exterminating agent. The hideous dragon-fly larva can be taken redhanded from his murderous life in the stream and studied in captivity with some larvæ of other insects. Then the children will learn what "the survival of the fittest" means.

The classroom, however, is not the best laboratory, even though it can be made a good one. Set the child once to observing in the schoolroom and observation in the great laboratory of our city children, the streets and parks, is sure to follow. Ere long one boy will announce that flies come from maggots—he has seen them in his father's store. A lesson in cleanliness is thus learned not easily to be forgotten. Another child will get the clue to the life history of the clothes-moth in those minute, whitish eggs and hungry grubs—another lesson in the ethics of dirt. Still another, more fortunate than his fellows in the possession of a backyard, will trace the metamorphosis of the yellow cabbage-butterfly. And so it goes, the interest in Nature, the mother, is begotten in her children, even those children who, by the artificiality of their lives, are forced away from her.

Some Typical Birds.

By Frank Owen Payne, Superintendent of Schools, Glen Cove, N. Y.

IN the study of birds let us remember that a bird, a real live bird, is preferable to a stuffed skin. "A bird in the hand" is *not* "worth two in the bush" when it is the song or the fascinating manner of birds that are to be studied. Let it also be remembered that classification of birds should follow rather than precede bird study. This is in direct opposition to the old book method which laid down a tedious classification that must first be memorized, after which the bird was introduced and fitted into the classification where it was supposed to belong. A boy having been asked to name the classes of birds began thus: "Birds are divided into ortopters, dipters, nemopters," etc. He had mixed his bird classification with that of the insects. Indeed we may pardon him for the mistake. He represents a very large class of pupils who have been required to cram their heads with words instead of ideas.

He who knows one bird well, knows much about all birds. The careful study of a feather as to its parts, development, varieties and adaption to use is essential to a knowledge of birds. The form of beak and foot are worth much special study; indeed the study of the skeleton of a bird, especially that of the feet and wings, is needful to a complete understanding of this wonderful mechanism. The writer has found that the wing bones left from the table and the turkey feet are excellent material for bird study.

Obeying the *dictum* of Commenius, bird study should begin at home. The hen, the duck, the dove, the robin, the hawk, the chimney-swift, etc., suggest common types for study.

The hen is a good example of scratching bird. This bird is worth much study and is an excellent subject to begin with, (1) because of its abundance; (2) because it stands as a type; (3) because it may be taken into the schoolroom if necessary and observed there from day to day. A teacher of my acquaintance brought into the schoolroom a setting hen with her nest of eggs just previous to the hatching, and kept her there until her brood was several days old. Lessons on the hen may be followed by others on the other *rasores* but classification should not be forced. Turkeys, pea-fowls, guinea-fowls and grouse are so similar to chicks that their family characteristics are quickly discovered.

The characteristic differences in the sexes is easily discovered and should receive attention. The rooster's comb and wattles, the turkey's curious head appendages and strangely colored skin about the head, and the peacock's magnificent tail and crest deserve special study.

The duck may be taken as a type of aquatic bird. The bill, the feet, the position of the legs upon the body, and the dense plumage are worth much attention. Geese and swans are not hard to see, especially the former, while the latter often grace the city parks. Other swimmers are not so abundant, but gulls are numerous near large bodies of water, while the divers are so rare as to be hardly worth study in the school, unless it be through preserved specimens and pictures. Aerial birds are common enough. The dove is so common as to prove a nuisance in many places. Its close relationship to the scratchers on one hand and to the perchers on the other makes it a good bird to follow the chick.

The robin, the blue bird and the wren are easily studied. It is sufficient to study song birds in the field. Sprinkle crumbs on the ground and take your position inside the house. Birds will very soon come and feed. If this practice be followed for a time the birds will become so tame as to remain, even when you walk out quite near to them.

In this way the writer has attracted many uncommon birds to his home. During the winter and spring of 1900-01, orioles, tanagers, buntings, jays, wrens and many other birds came to feed on crumbs thrown upon the lawn for them. A piece of suet nailed to a tree attracted hundreds of feathered songsters to its vicinity.

Ostriches and other birds of distant lands can only be studied in parks, museums and by means of pictures; but these means are quite enough if the commoner birds have been thoroughly studied.

The woodpecker is best studied in the leafless woods. Here his curious feet, so admirably adapted for climbing, and his hard bill and powerful head may be easily observed. The parrot in his cage exhibits feet of similar form, and his manner of climbing over his cage is well worth observing, if a parrot is available. Wading birds are not abundant, but they are not so uncommon as might be supposed, and any observer who quietly watches by a brook or pond will be rewarded by seeing some bony-legged, long necked, long billed bird standing in the water watching for prey.

The hawk and the owl may serve as types of prey. Their powerful hooked beaks and talons, so admirably adapted for seizing and tearing prey, are their most distinguishing characteristics.

Too much can not be said in favor of field-work on birds. Here modes of flight, hovering, soaring, etc., are to be observed; here manner of feeding, protective coloring, nests, characteristic songs and call notes can best be studied.

The Migration of Birds.

By Witmer Stone, Conservator of the Ornithological Section, Academy of Natural Sciences, Philadelphia.

As is perhaps generally known, every species of bird has a definite breeding range, within the limits of which all the individuals are confined during the nesting season. The ranges of some species are of course very extensive, while those of others are quite limited. In addition to the range of the species, we find that individual birds usually return year after year to the same immediate vicinity, sometimes to the same bush, to rear their broods of young.

After the nesting season, however, birds leave their breeding ranges and for the rest of the year are wanderers, more or less. Some species never get far from their native haunts, confining their roamings to short distances, influenced mainly by the abundance of food.

Others travel southward, after their young are on the wing, and winter hundreds and even thousands of miles from their summer homes.

To the first class belong many birds of the tropics, whose migrations—if such they may be called—are irregular and dependent upon the effect of the wet and dry seasons on their food supply. Here also are to be placed certain hardy birds of the temperate regions, which are resident in at least a part of their breeding range throughout the year, though we cannot always be sure that the individual birds that we see in winter are the ones that nest with us.

In the Middle States, south of the mountains, we have a number of such birds: several hawks and owls, the downy and hairy woodpecker, crow, jay, white-breasted nuthatch, meadow lark, goldfinch, song sparrow, etc., all of which may be seen every month of the year, and are hence called residents. All our other birds are migrants.

Any such classification is of course relative to the special locality under consideration, and does not imply that our resident species do not migrate anywhere within their range. On the contrary, many of them farther north are only seen in the summer, and are of course not residents for that locality.

Carrying our classification further, we can group our migrant birds into three classes, according to the time of their occurrence: (1) those that nest with us, like the barn swallow, house wren, catbird, etc., but go south for the winter, are known as summer residents; (2) those that nest farther north, where the climate is cooler, and are seen in our vicinity only in the winter, as the snowbird,

tree sparrow, winter wren, etc., are winter visitants; (3) those that nest to the north and winter to the south of us, and occur in our neighborhood only for a short time during their travels, are transients, such as the hermit and olive-backed thrushes and most of the warblers.

Let us now look into the cause of this migratory movement. The shifting about of certain resident birds from place to place has already been ascribed to a search for food, but the regular periodic migration which takes a bird from its summer home within the Arctic circle to a winter abode in South America or Australia is a different matter.

This habit, which is now hereditary, probably originated at the same time as the present seasonal changes in our climate. We learn from geological evidence that conditions were at one time very different from those that prevail on the earth to-day. The northern hemisphere, which at an early period supported many animals now found only in the warmer countries, became intensely cold during what is known as the glacial epoch, and was covered with a great sheet of ice, reaching in America southward to about the latitude of New York City. The cold undoubtedly killed off many species of animals, including birds, and forced others southward beyond their former range. Later, with the retreat of the ice, there was naturally an effort on the part of the birds to push north and reoccupy territory again made habitable, while the successive recurrence of the cold or winter season continually forced them back again. The same conditions continue to-day, though the cold season is shorter and the permanent ice is now limited to the Arctic regions, so that the hardiest birds can penetrate in summer well towards the pole.

The hereditary impulse and the change of climate are undoubtedly still the strong factors in maintaining the habit of migratiou, but there are other potent causes. In the fall the abundance of food has a strong influence, and many hardy birds remain well to the north in seasons that yield a large berry crop, while in years of failure they migrate promptly. In spring also the physiological excitement incident to the approach of the breeding season makes birds uneasy and restless, and no doubt acts as an impulse in starting them on the northward flight.

The extent of the migration in different species of birds is an interesting phase of the subject and one difficult to explain. It is reasonable to expect certain delicate, insectivorous birds to travel well to the southward to escape the cold, which must prove equally destructive to both themselves and their prey; but why the plover and sandpipers, which nest close to the snow and ice of the Arctic, should extend their winter flight beyond the equator, is hard to

understand. Of course, the idea that they nest again in the southern hemisphere is wholly erroneous.

Of our more common birds, the majority of the warblers, many thrushes, the orioles, tanager rose-breasted grosbeak, bobolink, indigo-bird, etc., winter as far south as the West Indies, Central and South America; many others are content to stop in Mexico and our Southern States, while the robin, bluebird, grackle, red-winged blackbird, hermit thrush, myrtle warbler, etc., winter regularly just south of the Middle States, and in smaller numbers or casually north of Mason and Dixon's Line.

Perhaps the most wonderful thing about migration is that we see so little of it. Robins and blackbirds and other species, which gather in flocks, we of course see flying overhead in the spring and fall, just as we see the V-shaped files of ducks and geese, but where are the thousands of smaller birds?

The answer is that, with the exception of birds that habitually flock like those just mentioned, nearly all our birds migrate at night. Let anyone go out in the country on a clear night during the period of migration, and he will be pretty sure to hear the chirping of the passing birds far overhead. Or, if he has access to a telescope, let him focus it on the moon as it rises over some river valley and note the passing specks of birds, which will be sometimes quite clearly outlined against the bright disc. The lighthouses of our coast furnish another means of noting night migration, and from the platform surrounding the light many a passing bird may be seen, attracted by the brilliant glow.

The method by which birds perform their flights and find their way back to the very tree, perhaps, where last year's nest was built, is, without doubt, the most marvellous part of the whole phenomenon of migration.

The sum of the evidence so far collected on the matter seems to show: (1) that birds start to migrate only on clear nights; (2) that they shape their course by a "sense of direction," either wholly internal or aided by the other senses, guided by such prominent landmarks as river valleys, coast lines, etc., which are clearly defined on a clear night when viewed from above; (3) that old birds which have been over the course before probably act as leaders, not necessarily to their own families, but to a more or less heterogenous scattering flock of many species. It would also seem that adults always precede their young in the fall, the latter probably following the lead of later migrants of other species.

The really wonderful part of the whole matter is the action of this "sense of direction," by which birds shape their course. This so-called sixth sense, or orientation, supposed to be located in the

semicircular tubes of the ear, is well known in the carrier pigeon, and is familiar also in the dog and horse, as well as in the savage, all of which can find their way over a route they have once travelled, apparently independently of the exercise of any of the familiar senses. Pigeons packed in baskets and taken by railroad to a distant point return home with a regularity and rapidity that precludes all possibility of chance, while they have been unable to see anything of the route over which they travelled in the basket. Exhaustive experiments made in France, and described in several papers by Capt. Gabriel Reynaud, seem to prove that a journey once taken is indelibly impressed upon the pigeon, so that as soon as opportunity offers it can retrace the course. Moreover, pigeons that were for one reason or another forced astray, even though accidentally quite near their home, would, as soon as they realized that they were wrong, retrace their flight to the distant point where they were liberated and make a fresh start home from there.

With what has been proved in the case of pigeons we can no longer doubt that orientation is the most potent factor in guiding the wonderfully accurate flights of wild birds. The pigeon experiments also showed that young birds liberated for the first time often followed old birds which had been brought from different localities and liberated with them, though eventually they retraced their route and sought their own home. Their habit of following has also a direct bearing on wild birds, as it illustrates the way in which young birds perform their first migration by following old birds, often of a different species.

Birds usually solitary begin to flock to a certain extent early in the fall or late in summer. We see a variety of species feeding together in the woods, and a single note of alarm starts them off, perhaps joining some other mixed flock as they settle again to feed a little farther on. Such scattered assemblages as these join together to form the migrating army of the night, and continually add to their numbers as they go along. The individuals are apparently not closely bunched, as are birds which habitually flock, but manage to keep within hearing of each other, and continually chirp as they fly. Early in the morning they settle down to feed and rest, and take up their flight the next favorable evening. The fall migration is generally somewhat lagging and protracted, but in spring the movement is a most rapid one, and an unusually warm day in early May will bring a perfect "wave" of warblers, and woods that yesterday were almost deserted are to-day fairly swarming with bird life.

Birds are often overtaken by storms or clouds while on their nocturnal flights, generally with disastrous results. Like most wild

animals when bewildered, they rush toward a light, and thousands annually dash themselves against the lighthouses of our coasts.

At Atlantic City, in a single autumn, over four hundred struck the lighthouse and were temporarily stunned, while ninety-two were killed outright, and the Liberty Statue in New York harbor has proved equally destructive. In the very center of Philadelphia the City Hall tower, which rises to a height of 525 feet, and is surmounted by electric lights, also destroys many birds during the migrations, though miles of thickly-built city stretches away on all sides, where no wild birds are ever seen. During the year 1899 no less than 452 specimens, representing over 40 species, were gathered on the tower and eaves of this building.

The uniformity in date of arrival of spring migrants at any given locality is interesting, as showing how regularly the migratory impulse must act through successive years, while a comparative study of the temperature of the season and the character of the weather will generally account pretty closely for the discrepancies. The following observations, taken near Philadelphia for eight successive seasons, will give some idea of this, while it may be added that observations recorded by William Bartram in the same vicinity, about one hundred years previously, indicate that the dates were about the same then as now:

	1885.	'86.	'87.	'88.	'89.	'90.	'91.	'92.
Chimney swift	Apr 22	Apr 23	Apr 22	Apr 20	Apr 15	Apr 22	Apr 16	Apr 27
Baltimore oriole	May 5	May 4	May 2	May 2	May 7	May 1	May 1	May 3
Barn swallow	Apr 22	Apr 19	Apr 21	Apr 12	Apr 22	Apr 19	Apr 19	Apr 24
Oven-bird	Apr 30	May 3	Apr 29	Apr 30	May 3	May 3	Apr 29	Apr 30
Catbird	May 2	May 4	May 3	May 5	May 5	May 5	May 4	Apr 30
Wood thrush	May 2	May 1	May 1	May 1	May 3	Apr 30	Apr 23	May 2

Elevation has just as much effect upon migratory animals as it has upon climate and upon distribution. That is to say, birds arrive much later in colder mountainous regions than in the low-lying valleys, and points along the river bank always report earlier arrivals than those on higher ground a little farther back. It will, therefore, be seen that localities on the same parallels of latitude will not have the same dates for the arrival of their birds, but localities on the same isotherms, as a rule, will.

Migration in the lower Middle States begins about the middle of February with the arrival of the blackbirds, robin and grackle, and continues until the last of May or first week of June, reaching its maximum about May 1 to 10, when the warblers pass through, and when careful observers can see from 60 to 70 species of birds in a single day. Return migrants begin to appear early in August and continue until the end of October or early November, when the last of the early spring species withdraws to the southward.

Animal Industries.

By John Thom Holdsworth, Professor of Commercial Geography, Drexel Institute, Philadelphia.

I SHALL confine this paper to a study of animal food products or provisions. This will embrace a discussion of the leading animal resources of this country especially, and of the industries which grow out of them, notably the slaughtering, packing and dairy industries.

The bulk of the world's demand for meat products is supplied from cattle, hogs and sheep. These must be raised where grazing is abundant and land cheap, as is the case in North and South America and Australia. The densely populated countries of industrial Europe are compelled, therefore, to look to these regions for their supplies of meat products.

Cattle.

Of the 300,000,000 cattle in the world, the United States raises about one-seventh, or 43,000,000, which is twice the number raised by any other country, except India. This is due to the abundance of cheap grazing land and grain, together with a climate so temperate and healthful that the herds are almost free from destructive diseases.

Cattle may be classified as ranch or range cattle, which supply the packing and slaughtering industries, and dairy cattle, producing butter, cheese and milk. In the Eastern States and in all densely populated countries, such, for example, as Denmark and Holland, cattle are put to dairy uses; in the West, where population is sparse and plenty of cheap grazing land is found, the bulk are killed for meat. Indeed, the West is the greatest cattle country of the world. If the Red River Valley be called the "bread-basket" of the world and the Santos region of Brazil the "coffee-pot," then, with equal propriety may the range States and the corn belt be called the "cattle-pen" of the world.

The long-horned range cattle of the Great Plains are of Spanish-Mexican origin. The first herds driven up from Mexico throve upon the succulent grasses of the Texan plains, where they were allowed to roam over great areas of unclaimed grass land. Upon the completion of the Union Pacific Railway, Texan owners began to drive great herds northward to reach this new outlet to market. A dozen cowboys would start north with 2,000 to 4,000 head of cattle, which, grazing along at the rate of fifteen miles a day, reached a shipping point on the railway in first-class condition. It was found that the dry, bracing climate and the tough grasses of these more northern sub-arid regions were even more favorable for

stock raising than was Texas. So cattlemen, from shipping steers only, began crossing the Texan with better stock, with the result that the stockmen of Kansas, Nebraska, and even States as far north as Montana and Idaho, soon shipped as good beef cattle as the average from Iowa and Missouri.

Alas! the famous trails over which in the '70's and '80's millions of steers grazed on their journey northward are deserted. The days when the cattle kings made tremendous profits and lived in princely splendor are passed. The westward surge of a land-hungry people has been felt on the plains. The railroad has supplanted the old trails, and the barb-wire fence delimits the grazing ground. Ranching to-day requires larger capital, and ownership of great tracks of land and water rights. The free range land of to-day is confined mostly to New Mexico and Arizona. The Federal Government controls the land and permits free use of it for pasturing, provided neither fences nor pastures are constructed.

It is estimated that in Texas each head of cattle requires from fifteen to twenty-five acres of pasturage. The land may be leased at about three cents an acre or bought at from fifty cents to ten dollars per acre, depending upon location and grass and water facilities. It may be of interest to note that these leased lands, belonging for the most part to the State, yield a large revenue, which goes toward the maintenance of schools and asylums. Texas has some ranches of enormous extent. The greatest perhaps is the "X. I. T.," owned by the "Capitol Syndicate;" it contains about 3,000,000 acres. There has been a strong agitation in recent years to have the ranch territory split up into small holdings for the benefit of incoming settlers.

Since 1886, the year in which meat raising on the plain reached its topmost notch, ranch cattle-raising has assumed new features. Terrific blizzards and heavy snowfalls have wiped whole herds out of existence and have entailed such heavy losses generally that there has been in that region a decrease in cattle production,—and a consequent increase in the price of meat throughout the country. This increased price however is due more, perhaps, to improved methods of breeding, inspection and selection.

Nowadays, the great bulk of range cattle are sent to the corn belt to be "finished," that is, fattened for the butcher. This was begun on a large scale about 1895-'97, when the farmers of Kansas and Missouri were unable to market their enormous corn crops. In their extremity they bought stock to which they might feed their superfluous crop. Such excellent results were obtained that it became a regular system. A great deal of cotton-seed oilcake, too, is used for "finishing." It is cheap and fattening.

Texas is still the most important breeding state. She heads the list, too, in total production, with 5,235,000 heads; then follows Iowa, with 3,410,000; Kansas, 2,866,000; Illinois, 2,324,000, and Nebraska, 2,206,000.

Of the millions of steers raised annually on the plains and in the corn belt, the vast proportion are shipped to one of the great packing and slaughtering centers—Chicago, Kansas City, Omaha. Many are sent East, where, after being stall-fattened, they are slaughtered to supply the local market. Many more are forwarded to the Atlantic seaports for shipment "on the hoof" to European countries, especially Great Britain.

Inasmuch as cattle and hogs condense corn to about one-fifth of its bulk and weight, and reduce the cost of transportation in about the same proportion, it has become possible to extend the corn belt farther and farther westward,—and it must be noted that the packing centers have followed the concentration of swine and the great food staple, corn. So, to-day, the packing business is emphatically a western enterprise. It was begun in 1818 by a Yankee, Elisha Mills, in Cincinnati, still known as "Porkopolis." This city led the business for a quarter century, but in 1860 Chicago took the lead, which it has held to the present time. Kansas City and Omaha are only second to Chicago as slaughtering centers, and may in time dispute with her for first place. Other important packing centers are St. Louis, Milwaukee, Louisville, Indianapolis, St. Joseph, Mo., Ottumwa and Cedar Rapids, Ia., Sioux City and Wichita City, Cleveland and Detroit. Newport News, "the New York of the South," has recently assumed a place of some importance as a packing and shipping center.

It is said that we owe to Napoleon the idea of the great slaughter houses, he having instituted the abattoir in France about 1807. The unsanitary effects from private slaughter houses are avoided, and the great number of animals killed at one center permits of the utilization of all parts of the animal and of all by-products. The latter constitute a large item in the economic value of the animal. The great Chicago packing houses get more for the by-products incidental to the killing of a steer than from the meat itself.

A northern range steer weighing from 1,000 to 1,350 pounds will dress to about 500 to 750 pounds, yet nothing goes to waste. The blood flows along the floor to the reservoirs. The albumen is extracted chemically and is used for the fixing of colors in calico printing and also in the finishing of leathers. The best blood is used for refining sugar; that of inferior grade is used in the manufacture of buttons; the poorest quality, when mixed with other offal, is dried and converted into fertilizer. The horns can be made

pliable, split into plates, welded together and under heat given various colors. They make admirable imitations of the high-priced tortoise shell, and are manufactured into combs, buttons, umbrella handles and ornaments of many kinds. The tips of the horns are made into mouthpieces for pipes and the scraps are utilized by florists as fertilizer. The pith extracted from the horn yields the finest grade of gelatine.

The knuckles and shanks of the animal, after being boiled and cleaned, are made into knife handles, tooth brushes, buttons and various articles in which bone and ivory are used. The scraps are used by the manufacturer of bicycles and screws for case-hardening steel, and are also used for poultry food. The white hoofs are shipped to Japan and to Europe to be made into buttons and ornaments. The dark or damaged hoofs go to the kettle to be boiled for glue. Hoof meal, a valuable fertilizer, is also made from part of the hoofs. The feet yield neats' foot oil. The coarse bones are either carbonized and sold to the sugar refiner or turned into fertilizer.

The hair is manufactured into felt, the cheaper grades being used for the insulation of ice-boxes and refrigerator cars. It is also used for mixing mortar. The better grades are used in the manufacture of blankets, saddlery, boots and hats. The fine hair from the interior of the ear is used for fine brushes. The tuft of hair on the end of the tail is turned into curled hair for upholstering. The hide goes to the tanner. The tongues and tails are well-known articles of commerce, while the cheeks are turned into sausages and the lips pickled.

One of the most valuable by-products is oleo oil, which is pressed from the fat. It is largely used in the manufacture of oleomargarine or butterine. Europe buys a great deal of it to be used in the manufacture of margarine. Glycerine, a part of the fat that will not saponify, goes to the bottom of the kettle with the lye, and from it are made crude glycerine, dynamite glycerine and pure glycerine. The tallow and grease are made into various kinds of soap.

The intestines are largely used for sausage casings. They are also used in breweries for lining pipes through which beer is passed so as to prevent contact with the metal. Parts of these, too, are sold separately, to be made up into gold-beaters' skins. The bladders are sold for holding snuff, and are used by druggists to cover bottle-stoppers to retain the essence of perfumes. The bile, known as ox-gall, is used for cleaning and in painting. The undigested food of the stomach is compressed and made into an excellent quality of cardboard. Rennet, used for curdling milk in cheese

making, is obtained from the stomach of young calves. Pepsin is another product from the same source, though the hog furnishes a more convenient and abundant supply.

During the slaughtering operations water is flowing constantly and is being charged with offal of all sorts that is carried into the reservoirs. From this liquid mass is extracted the meat and fat, which is made into axle grease, soaps and candles. The residue after the water is evaporated goes into the final product of the abattoir, fertilizer.

The dressed beef industry was of no account until 1876, and its rise was due to the invention of refrigerator cars. It has reached an annual business of 250,000,000 pounds. A single establishment slaughters thousands of cattle daily regardless of season, loads the chilled carcasses into refrigerator cars and delivers the beef to the cold storage warehouses of the eastern cities with no change of temperature in the beef, selling it to the local butcher in better condition than he could possibly slaughter it on his own farm, and at a lower price.

Since 1879 meat canning has been a very large factor in the slaughtering and packing business. The meat cut for canning is pressed into cans by automatic machines. The cans are then capped and soldered, hermetically sealed and "processed," which make the meat proof against climatic changes. Thousands of tons of canned beef, tongues and soups are put up annually. But with the growth of the refrigerated beef industry the trade in canned beef and pickled or salted beef has declined.

Other commercial products incidental to the packing industry are mince-meat, beef extract and pepsin. Many related industries have sprung up to utilize the by-products. Thus a well known Chicago firm has a complete tin shop, where they make all the cans required for the canning division of their enormous business. Mr. Armour once made the suggestion that the packing house of the future might include a tannery, a shoe factory, a cloth-mill and a mammoth tailor shop.

The process of slaughtering hogs is very much like that of cattle. It takes only about five minutes from the time the hogs, dripping from a shower bath, are driven in lots of fifty into the death chamber until the carcass hangs in the chill room. Labor saving devices are adopted in everything except the killing, which is done by hand. Nowadays even the scraping is done by machinery, though hand scrapers subsequently go over the hog to make up for any omissions of the machine. It is said that the scraping machine does the work better than men could, certainly with a great saving of time, and leaves the bristles in better condition for subsequent use. After

twenty-four hours in the cooling rooms the carcasses are run out on rails to the cutting tables, where with wonderful rapidity they are divided into hams, shoulders, short ribs and other cuts well known to the trade. Next these cuts go through shutes to the curing cellars, where they lie for two months in dry salt. Hams, shoulders and pieces for bacon are put in vats of sweet pickle, where they lie for a similar period. Finally comes smoking, a twenty-four hour process, after which the cuts are stored to await shipping orders.

Although the packing industry has been adverted to in connection with the slaughtering of cattle, packing in its literal sense chiefly affects swine. The last quarter century has seen a great development of this industry. Improvements in the chilling and refrigerating processes have made summer packing possible, so that fresh hog products can be supplied through the entire year. Summer packing proceeds from the first of March to October. The total number of hogs slaughtered annually is about 40,000,000, the greater number of which are fattened on the corn of Illinois, Missouri, Kansas and Nebraska, the leading swine raising States. About one-third of our annual corn crop is turned into hog products. After the United States the greatest swine raising countries are Austria-Hungary, Germany and Russia. Canadian and Danish hams and bacon usually command higher prices on the British market than the American products because the latter, having been fed exclusively on corn, are too fat.

In this country sheep are raised more for wool than for mutton; yet the slaughtering centers kill millions of sheep every year. Mutton is a comparatively small item in our export of provisions, but great quantities are consumed at home. Indeed, we have degenerated into a mutton eating people. The countries raising the greatest number of sheep are, Australia, with over 100,000,000; Argentina, 80,000,000; Russia, 48,000,000, and the United States, 42,000,000. Argentina, Australia and New Zealand ship millions of frozen carcasses to European markets in ships specially fitted with ice chambers for this trade.

Markets.

The census returns of 1900 will show that our slaughtering and packing industries turn out an annual product worth $700,000,000. We slaughter annually seven billion pounds of beef, six billion pounds of pork and the same of mutton, and about eighty million pounds of veal, besides handling eleven million pelts, nine million hides and the by-products of thirty-five million animals. The best market for these products is, of course, domestic. We actually consume at the rate of one-eighth of a pound of meat per day for every

man, woman and child in the country. Yet we have an annual export trade in provisions of over $197,000,000.

Our export of live animals aggregated $52,000,000, the chief items being: Cattle, $38,000,000; horses, $8,900,000; and mules, $3,210,000. The stimulated export of horses and mules has been due to the South African war.

Great Britain furnishes the best market for our export provision trade. Thus, 80% of the bacon and ham, more than 50% of the pork, and about 33⅓% of the lard exported from the United States is marketed there. Moreover, she buys practically all of the fresh beef, four fifths of the canned beef, nearly one-half of the cured beef, and over a third of the tallow exported from this country. Germany takes about one-third of our lard and a fourth of our oleo. The Netherlands, though, is the best market for oleo, taking about 50% of our export. After the United Kingdom our next best customer is Continental Europe, then the West Indies and South America.

Dairying.

The most important dairy products are butter, cheese and milk. The demand of large cities creates a steady and uniform market for fresh milk and compels the raising of great numbers of milch cows near the city, for milk cannot be transported over long distances. The United States raises annually for dairy purposes alone 17,000,000 milch cows.

For a long time New York was the banner dairy State, and still leads in cheese (producing one-half of the total product) and in butter made on the farm. Wisconsin is second in cheese, followed by Ohio, Illinois, Vermont, Iowa, Pennsylvania and Michigan. In co-operative butter making Iowa takes first place, followed by Illinois, Pennsylvania, New York, Wisconsin and Minnesota.

Our dairy produce is now worth annually about $500,000,000. Most of our home cheese is Cheddar cheese, though we are beginning to make new kinds and imitations of foreign cheese. The great bulk of our dairy produce is marketed at home. Our export of cheese during the last fiscal year was only $3,950,000, and butter $4,000,000, the most of which went to Great Britain. Against our export of cheese should be contrasted that of Canada, the great cheese country, which exports annually $15,000,000 worth of cheese. The decline of our cheese export trade is due to the fact that for many years we allowed "filled" and "skim-milk" cheese to be exported without brands to distinguish their true quality. Naturally all of our cheese became discredited both in foreign markets and at home. Canada has rigid laws prohibiting the manufacture or sale of imitation cheese. Our import of cheese last year, mostly from Italy, Switzerland and France, was over $2,000,000.

Plant Ecology for the Elementary School.

By Francis E. Lloyd, Adjunct Professor of Biology, Teachers' College.

IN presenting this paper it is taken for granted that were a all agreed on at least two weighty and fundamental points. The first is that nature study, as we are compelled by custon now to call it, by which we mean a study in the elementary school of organic and inorganic nature in a correlated fashion, is of very great value, because it enlivens and vivifies the work by bringing out new points of view, by keeping alive the love of nature, which, to use a well-worked phrase, appears to be innate in us all, and to be especially keen in normal children. In other words, it pleases, interests and then furnishes a basis for all kinds of work which is useful in broadening and enriching the school part of life—for, old as the idea may seem to many, we are very far from making it such.

The second point is no less important, and is possibly of more importance, though comparisons are in the educational field as odious as elsewhere. It is this: The value of training in scientific observation, in making mentally well-balanced people with independent thinking powers, with a *deep respect for facts*, who respect nothing but truth, is recognized as the greatest possible. It will be observed at once that I mean by thinking people those who think first inductively, a process simple enough objectively considered, but, like ethical precepts—commonly called preaching—exceedingly hard to manage as a part of our activity. The allurement attached to a view or opinion because it is one's own or because it appears, in an immediate though perhaps narrow way, to one's interests, is enough to overshadow many facts which militate against that opinion. So true is this that, in real life, a very small proportion of people are guided to their conclusions solely from ascertained facts; and, as to forming judgments, when they are in opposition to the interests of the individual—this is a phenomenon scarcely yet to be encountered.

It has been said that the method of teaching in science "shall be unfailingly rational; that facts, though essential, shall be rated as less important than the principles which underlie them."* By which the author quoted means, we take it, that the acquiring of a proper habit of mind with respect to the handling of facts is more important and fundamental in education than the accumulation of information. Respect for fact means that nothing shall be accepted as such until it has been subjected to vigorous examination by rational methods of thought.

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* Woodward, C. M. The Change of Front in Education. Science II., xiv.: 474. 1901.

And I believe that I am wholly right in contending that if nature study fails to do its part in education, it fails because the above outline principle is not adhered to. Of course, we do not shut out the factors which work toward the general end, but I would say this, that a scientific subject wrongly handled by what is known as an "attractive" teacher will surely do much more harm than if it were rightly handled by a less attractive, and so, presumably, less successful teacher. Personal charm, magnetism, as it is sometimes called, may in this way do a great deal of harm.

The title under which this article is placed calls for a discussion of plant ecology in the school. What, first, is meant by ecology? Although the word is of comparative recent coinage, the subject is as old as natural history. When we are considering the relation of an organism, plant or animal, to its environment we are studying the ecology. But let us see what all this means. We can understand best by taking a concrete illustration. A plant has the remarkable ability, not possessed by animals, of *manufacturing food*. To do this it must get hold of raw materials. These are various mineral matters and water in the soil, and, in the air, carbon dioxid. But in making food out of these the plant must do work, and very hard work at that, as is proved by the many attempts of chemists to accomplish the same thing in the chemical laboratory, the majority of which have been unsuccessful. Doing work involves the expenditure of energy, all of which, for the purpose mentioned, is derived from the sun in the form of light, and it can be shown that the process is, in some remarkable manner not yet understood, bound up with the presence in the plant of the substance to which the green coloring of most plants is due, namely, cholrophyl. Now, when we commence to study the plant from this point of view thus gained, we find numberless arrangements—mechanisms, so to speak—by means of which the plant gets the best amount of light for its own particular purposes, and the study of these arrangements and their relation to light constitutes ecological study. A moment's reflection will show that there is here involved a careful and exhaustive study of the *structure* of the plant and the *physiology* of the process of food manufacture, and it is only by this means that a fair idea of the ecology involved can be gained. The reader may now judge for himself whether ecology, in this sense, can be made a part of the elementary curriculum without asking the impossible of the pupil or not. Such intricate study is far too difficult for elementary students, calling, as it does, for very accurate experiment and prolonged observation, both direct and indirect.

To be sure, the same topic may be approached in a different way, and may be made just as accurate ecological work, *provided*

it does not read into the facts something which is not there. Take, or instance, the position of leaves. This is a topic of the general problem above indicated which is often dealt with in text-books. When illustrations are given, the most striking leaf mosaics ground, and the impression one gets is, too often, that every plant is trying to get the most possible light. This is thoroughly unscientific, and is speculative far and away beyond the facts. What the plant is after is not the most possible, but, for its purposes, the *best amount* —technically termed, the *optimum* of light. Botanists themselves are far from coming to agreement about the, to many minds, apparently obvious conclusions involved in the position of leaves.

What, then, if anything, can be done in ecology? This: Very many facts may be observed and a certain amount of generalization may be arrived at. Simple experiments may be carried on and the casual relations, as far as possible, be determined. To illustrate: A child in the first grade picked up some yellow leaves of grass on his way to school and asked the teacher why they were yellow. At my suggestion the question was answered—experimentation as follows: Some grass seeds were planted in two flower pots, and one was covered by a third flower pot, with the hole closed by a cork. The seeds in the uncovered pot germinated in a few days, but, by previous agreement, no observation of the seeds in the covered pot was made. The eagerness with which the final observation was looked for fully justified the expectation that the lesson would never be forgotten. At the close of the stipulated period the seedlings in the covered pot were examined and the obvious answer to the question was obtained. But how did it come that yellow blades of grass were picked up outdoors? The answer was not far to seek. Piles of cut grass had been left by the grass-cutter, and these had shut out the light from the grass beneath. I mention this at some length to show, approximately, how far this kind of work can be carried out. The experiment does not tell us why a plant is green, but only that this plant when grown in the dark fails to become green, and, therefore, that the normal processes in it are in some way related to light. Note further, that the plants "like" the light. This is quite a false and anthopocentric interpretation which may never properly be indulged in—nonsense, in short. Elementary teaching in nature study, to be good and permanently useful, must be purged of this sort of thing.

In this sense of the term ecology, then, we may reasonably expect that not a little most valuable work may be done under the guidance of a thoughtful teacher, and it by no means supposes that that teacher shall be a professional botanist, or zoologist, or both, and more into the bargain, desirable as one may feel it to be when one

is pelted by impossible questions, but only that he will be true to the principle of not going beyond the facts. In this way much natural history work may be done which at present claims the attention of the high school student. It will now be my object to attempt to indicate a few lines of work which may be adapted to pupils in various grades, though I cannot at this time do more than this.

The teacher should, as far as possible, keep uppermost the idea that *something is going on.* Every part of a plant is involved in change either in itself or as a result of the behavior of neighboring parts. To be sure, a part which has passed into a non-living state in itself may not be changing; but such a part may nevertheless be acted upon by another living part, and the changes in the non-living is then a clew to what may be going on in the living.

The point is this—that it is very easy for us to regard a plant as a something which is not, rather than one which is, in action. The absence of activity in the way of motion leads unwarrantably, but nevertheless frequently, to the belief in absence of activity of all kinds. We should therefore try in every way to look at plants from this point of view, and if as teachers we get into the habit ourselves, we shall then help our pupils into the same happy frame of mind. It is my purpose in these suggestions which follow to indicate how studies may be carried out from this point of view.

Winged Seeds and Fruits.

Up to the present time the work which has been done on this topic has about always been confined to observation of the materials as *still* rather than in movement. To be sure we have read stories about the flight of seeds and fruits, and have perhaps been overpersuaded as to the value of the structures referred to. I would suggest that comparative studies be experimentally carried out to determine the *actual value* of these supposed organs of flight, to *determine their efficiency* in still air and in wind. To say that these structures are good for this and that purpose without making some sort of a test is scientifically and educationally wrong. Some short time ago in a popular magazine article a certain winged seed was described as possessing a sharp spur for protection from animals. Such an explanation may be correct. It is as unscientific to deny as to affirm, until some pertinent observations have been made.

The following simple experiments, which may supplement the usual observational work, accompanied by sketching, may be done.

Determine the action of the wing in a series of seeds and fruits in the following manner:

1. Holding a specimen a *given* distance from the floor in a *given* position, release it, and observe its departure from the vertical, and

the nature of its course. Repeat several times to see if the action is repeated invariably. See whether a change in the initial position affects the general result.

2. On an average windy day, repeat the experiments outdoors, to determine the effect of wind.*

3. Answer, from the above observations, the question as to the importance of wind in rendering effective the wings.

4. If field work is done, see if you can find any *winged fruits* from which the seeds, which are not winged, are scattered. Should you find such, it is obvious that the usefulness of the wing must be explained in another way. This is mentioned because it is always well for us to be on our guard against making too sweeping generalizations.

FRUITS AND SEEDS.

In the majority of cases the forcible scattering of seeds from the containing seed vessel is due to the mechanical conditions brought about by the drying of the tissues. In this process unequal tensions are set up which produce twistings in the walls of the fruits, accompanied often by sudden release of the parts, with the resultant seed ejection.† In some instances the ejection is due to the cramping of the smooth hard seeds between the sides of the valves of the fruit, as in the witch-hazel and violet.

Fruits may be gathered before fully ripe and their drying may proceed in the room, and the action of the parts accurately observed. The larger sorts are better for younger pupils.

Among the best for the purpose are the pods of the wild pea vines, and the fruits of the castor oil plant, which is plentifully cultivated in and about New York. Compare the behavior of the fruits of these two plants carefully and determine if the action is essentially the same in them.

Does forcible ejection of the seeds always take place in dehiscent fruits? Are there in such cases other means equally efficient?

In indehiscent fruits does an active propulsion occur? (The method of dissemination in the Virginia knotweed (*Poligonum Virginianum*), which is common in our woods, is a good illustration. Collect a bunch of stalks with fruits partly ripened and keep in water in the school-room. When ripe the slightest touch is sufficient to release the fruit.)

So far as possible determine accurately the distances to which seeds are projected by these means.

* It is idle to say the wind does so and so in a general way. *See* what it actually does.

† These tensions may be set up in other ways, but these are of less frequent occurrence and are more difficult to understand.

Determine cases in which dissemination is passive, carried on through the relation to animals, or other agencies.

What is the relative effectiveness of the active and passive methods of dissemination?

The Position of Leaf Blades (Mosaics).

The general fact that foliage leaves are concerned in receiving and absorbing light from the sun, and converting a part of it into energy, underlies all our interpretations of leaf position.

This topic offers excellent opportunities in field work.

1. Examine the twigs of various trees, shrubs and herbaceous plants, to determine whether the leaf blades of a given twig are arranged in the same way with reference to each other as in other twigs of the same plant. How does the *position* of the twig modify the case? See if rearrangements are produced by twisting or bending of the leaf stalks or stems, and at what point, if confined to a limited part? What relation does *shading* have to the matter?

2. Examine plants growing in different positions as regards the amount of light which they receive, and see whether the leaf mosaics are more or less pronounced according to environment.

3. See what part the *position of the leaves on the stem*, independently of the torsions of stem and petiole, plays in effecting a satisfactory leaf blade arrangement.

4. Can you find examples of plants in which the leaves are twisted from their original position so as to lie more or less in a vertical plane? A common wild lettuce* (*Lactuca scariola*), which is frequently met with in waste places, is a good example. If this plant is found and studied, see if all the leaves lie approximately in the same plane, and if this plane is a north-south one. Examine, with reference to this point, plants growing in the open, so as to be equally lighted on all sides, or near a rock or other object which cuts off the light from one side.

5. Rosette plants, or those in which a rosette of leaves is formed, as in dandelion and mullein. What is the form of the leaves of these plants? Compare as many as possible as to this point. Does the form of the leaf have any advantageous relation to the rosette arrangement?

6. Compare different rosette plants of the same kind, growing in different situations, as regards water, shade, association with other plants, nature of the soil. Note the habit or general appearance of the plant as a whole and the form of the leaves.

* This is one of the so called compass plants, and is a good one in its normal surroundings.

The Habits of Trees.

The general appearance of a plant produced by the position of branches and their development as affected by each other, and by other causes, is known as the *habit*. It is a very useful exercise to study the character and development of twigs of trees, and to determine how far the habit of a tree is conditioned by the position of its buds, and therefore branches. The question may be thus stated: How far does the tree differ from the form it would assume if all the branches developed? This is a good exercise in constructive imagination. For what reason does the suppression of certain buds take place?

Among the simplest examples for such an exercise are the maple and ash. The study will combine field work and school-room work. An outline may be made out somewhat as follows:

1. Take a maple twig with the leaves still attached, preferably if they are ready to fall away, and note that the removal of a leaf results in a scar. The form of the scar is determined by the shape of the base of the leaf stalk.

2. Describe the position of the buds as compared with that of the leaf scars. Are there as many buds present on the twig as you might expect from the fact that buds occur in the axils of the leaves?

3. Do all these buds grow? If not, where, with reference to the rest of the tree, do the buds grow the best? Examine a tree after the leaves have fallen, and see if the development of the branches has been determined by similar circumstances. Where do the branches grow best? In what position is the growth best distributed on all sides of the twig?

4. Does any other factor help to determine the habit of the tree, such as curvature of twigs? If so, in what direction do twigs tend to grow?

5. How is a relatively unfavorable position of a twig, with reference to the light, compensated for by readjustment of the leaves by movements? (Correlate with work on leaf mosaic.)

The Mechanics of the Stem.

It is of prime importance to the plant that the organs which support the leaves should have sufficient rigidity. This is accomplished by means of *mechanical tissues*, which by their texture and arrangement give at the same time rigidity and elasticity to the stem and petioles. The behavior of the plant to water is also important in this regard. A good many simple and very instructive experiments may be done to illustrate the relation to water, and to supplement the more essentially observational work on the mechanical parts.

Collect plants of various kinds and examine the stems to determine where the hard, rigid internal parts occur. If good sized stems are used, a good many such points can be made out in the more advanced grades, especially with the aid of a lens, if that is to be had.

Notice also the relation of these mechanical parts to the *form* of the stem, and examine the whole in the light of pure physical relations. Are the arrangements you find good from a mechanical point of view?

Some very suggestive experiments bearing on the relation of water to the rigidity of supporting parts may be found in Atkinson's "First Studies of Plant Life."

Changes in Bark.

Any topic which calls for the observation of changes which are taking place lead up to the most valuable conception which anyone can have of nature. These changes are, however, in many cases so slow that we may not observe them directly, but only indirectly. An illustration of this is offered in the changes which the bark of trees undergo as the diameters of the stems increase. Inasmuch as this increase takes place in all our native trees on the *inside* of the stem, and, further, as the growth of the outside layers of tissue does not keep up with the increase in the volume of the internal tissues, the outer tissues are sooner or later ruptured. Now this process is so slow that it would be quite impossible to watch it going on, but we can see every possible stage in the process, which amounts to the same thing. It is also to be noted that the process in any particular tree is quite regular and characteristic for that kind of tree, and in the end produces the characteristic *bark* by which it is possible in many cases to recognize to which it belongs.

To begin, we choose some tree of fairly rapid growth. Poplar is especially good. Examine carefully the surface of the youngest twigs for little oval dots scattered here and there. Look for these in older and still older parts until you are able to find tiny longitudinal rifts, which commence always at the dots seen in the younger parts. See if these rifts, as they grow deeper and more extensive, keep independent or run into one another, and with what degree of regularity.

Extend your observations to other trees and see how far the changes in one kind correspond to those in another. How far may the final bark characters be accounted for?

I have noticed that in many trees of rapid growth the amount of rifting in the oldest parts of the stem is so great that the newly exposed tissue can be readily recognized by their clean, unweathered appearance for some time during summer and fall.

Similarly one may observe in the course of a few days, or at the most two or three weeks, the rifting in the youngest twigs of the catalpa. For this purpose this tree is one of the best I know. The twigs may be gathered at any time during winter, and if kept inside a bottle, with a little water in the bottom, and with a loosely fitting cover, will soon commence to show growth in the *lenticels*, as the little dots spoken of above are called. Those near and in the water grow quite remarkably. This sort of an experiment is valuable in addition as a striking proof that the tissues of the twig are alive, and further, that active changes are in progress, even though the buds are not growing, at least to an observable extent * Try twigs of other plants, including willow.

Behavior of Seeds Toward Moisture.

1. How much water do seeds absorb? Using some large, easily handled seeds (beans, e. g.), take a weighed amount, andallowing them to stand in water, over night, for a given number of hours, weigh them again. The difference in weight will give the amount of water absorbed. Make the result real by weighing out the amount of water in a bottle. The value of the metric system may be made clear by this means.

2. Does water enter the seed at any part in particular? For pupils who are able to appreciate the markings on the bean seed, it will be instructive to seal up the minute opening (micropyle) with hot *paraffin* in a dozen seeds and observe whether they absorb water as rapidly as those left unsealed. It is obvious that this method may be applied to the study of other seeds.

The seed coat, as it absorbs water, swells and so wrinkles. This wrinkling may therefore be taken as an index of water absorption. Place a dozen beans or peas in water and observe them at intervals of a few minutes to determine how long it takes for an obvious amount of wrinkling to occur, and at what point the wrinkling commences.

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* Additional points of interest are suggested by L. H. Bailey, in "Lessons with Plants," p. 69.

Common Trees and Their Fruits.

By La Roy F. Griffin, Principal, Frye School, Boston.

TREES awaken interest because they play so large a part in the features of any landscape. One-half the charm of the villages nestled among the White Mountains and the Adirondacks finds its source in the varied hues which tint the foliage of different species of firs or maples, outlined against the mountain's rugged sides, or projected against the sky, gilded by the summer sun. Remove the forests, cut down the trees scattered in field and pasture, and who would ever go to the country to commune with nature? Therein lies the charm of their acquaintance. So the first effort of the true teacher must aim to get his pupils to know the trees themselves; to study them first hand, as they grow. The differences in the general appearance of the various species as they are seen from a distance must be emphasized; for each species has its own general aspect, as seen projected against a distant hill, or the open sky. Yet each single tree possesses an individuality of its own, and this the student must learn for himself. The true lover of nature comes to know the trees near his home as personal friends with whom he holds sweet converse. And in the near view the student must become acquainted with the markings of the bark and leaf, so that a glance will tell him whether he sees an old friend, or he has met a new acquaintance.

The trees which generally make the northern forest are of two classes, the deciduous and the evergreen. The former ripen the leaves with the close of summer and drop them, the swelling buds which make the next year's growth now preparing for resistance to the frosts of winter, pushing them off by separating the stem from the sustaining branch. Trees of the second class carry their leaves for more than one season, commonly for three, ripening them gradually, so that the tree is constantly clothed with verdure. This makes a distinction that all, even the youngest children, can see clearly.

Trees grow with periods of rapid enlargement, followed by periods of total rest, or of retarded growth, that is, of partial rest. Deciduous trees rest completely from the time when the leaves fall until the warm sunshine of the returning spring awakens new life. These alternate periods of rest and active life are marked by rings of growth. In some trees, the wood produced in the alternating periods differs so little that the rings of growth are not easily separated. This is the usual condition of the wood of the evergreens. But in most of the deciduous trees each ring of growth consists of entirely distinct forms of fibre, one of which is more hard and dense

than the other, and most of the channels through which the sap moves are formed in the latter.

In all trees there is a marked difference between the heart wood and the sap wood. The former is too old for growth. In fact, it is essentially dead. In extreme cases, indeed, it may be removed and the tree can yet grow and thrive. But the sap wood is soft, filled with sap, and the most of the cells are still living The year's growth is placed just outside of the sap wood, so that new layers are constantly added as long as the tree retains its vigor. This manner of growth belongs to both classes.

It is well to remember that rings of growth do not record the passing years, but the alternations of periods of rest and active growth. In the colder regions, these periods commonly coincide with the years; but if any unusual conditions stop the growth, and so give an extra period of rest, the record in the rings shows more than a single ring in a year. In tropical climates, such trees as are external growers, and not point growers, commonly show two rings each year.

This article aims to present the important features of those trees which are most likely to be seen by the student who is a lover of nature. Of these, the classes which are most common come first. Along with the tree itself, the nature of its fruit is given, and the peculiarities of its wood. Where useful for lumber, the articles made from it require mention.

I. *Trees of the rose family* (*Rosaceæ*). Although the rose family is a very broad one, and plants whose blossoms are roses are found everywhere, and at nearly all seasons, yet but few trees belong in this class. But these are widely scattered, and very familiar, since they include the common fruit trees. The distinctive feature of the blossom is found in the highly colored petals, set commonly in one circle (whorl), with the essential organs (stamens and pistils) set within. The whole is commonly surrounded by an insignificant little green calyx that appears as the "bloom end" of the ripened fruit. The blossoms are nearly always perfect, and many require the aid of some insect to secure fertilization.

The apple is the finest general specimen of a fruit tree (*Pyrus malus*). It is a cultivated tree, and whether it was native to this country or ran wild from seeds brought from Europe in the days of the early settlers, cannot now be determined. At all events, the cultivated apple is a very different tree as well as fruit from the wild. The pear (*Pyrus communis*) grows much like the apple, though in the apple the limbs bend downward much more than in the pear, so giving the apple tree a more nearly globular form. This makes the apple tree the more beautiful tree, when in foliage.

The other common trees of the rose family are the cherry, the plum and the peach. The cherry is by far the largest, the most hardy, and the noblest of the fruit trees. In the wild state, when growing in the woods, particularly of the variety known as the black cherry, from the color of its fruit, it often attains the height of eighty feet, and may be from thirty inches to thirty-six through. The plum is a dwarf beside the cherry, yet the general shape of the tree itself is more beautiful, while the peach is small, tender, and gives the impression of a weakling.

The chief value of all these trees lies in their fruit; yet at the season when they are in blossom they are all exceedingly beautiful. The apple, in fruitful seasons, and most of these trees bear fruit only in alternate years, is covered completely with blossoms near the end of May—at first a pale pink, and then fading out nearly to white. As these petals drop, the ground beneath looks like new-fallen snow. The pear blossoms nearly at the same time, yet commonly a few days later, and the cherry comes earlier than either. Its petals at first give a distinct shade of red. The peach blossoms first among the fruit trees, its sap awakening its buds at the first kiss of spring; and right here lies the danger, for very often its buds swell and even open before the frosts have ended.

The fruit of the apple and pear grows upon a simple plan. It is produced by an enormous increase of the top of the stem and ovary which surrounds the seeds. At first, it consists of woody matter only; as the seeds mature, the hard, woody material (largely cellulose) is replaced by a soft pulp, which consists mainly of water, but which carries some acid in solution. But the fruit of the pear is commonly softer than that of the apple, and its juice consists mainly of sugars in solution. The whole is arranged in layers, just as in the flower itself. This may be clearly seen by cutting a thin slice of an apple just above the core and holding it up to the light. The purpose of the apple and pear is to attract animals to eat them and swallow the seeds, many of which pass through the intestines uninjured, so scattering the seeds.

The fruit of the cherry is a juicy pulp with no signs of division, which encloses a single seed whose covering is very hard (the drupe, or stone fruit). Plums differ very little save that they are larger and show some signs of division. Peaches grow according to the same plan but the stone is rough and is attached to the fibres of the fruit. While all the other fruits are covered with a smooth skin, the rind of the peach is rough and is covered with a sort of down called the bloom, which is almost poisonous to some animals before the peach is ripe, and is always disagreeable.

The Timber. The wood of nearly all the fruit trees is hard

enough to polish well, so that when the tree is large enough to be sawed readily the timber can be used for ornamental purposes. Hence, cherry finds a place in beautiful desks and interior furnishings, and of the varieties the black is the best. It is of a light red when first cut, but it darkens with age. The richest interior of cars are made of cherry that has darkened with age.

The apple furnishes a wood that is dark red in color, very rich, and growing still richer as it darkens with age. Little use can be made of it, since logs more than three feet long are rare, except for wood carvings. It cuts well under the chisel, and its pungent odor prevents insects from attacking it. So carvings in apple tree are unusually lasting.

II. *The Maples* (*Acer Family*). The trees of this family are very attractive and beautiful. Some of them are very stately, so that maples are much used for shade trees. They blossom early in the spring with yellowish green or fiery red clusters that show in patches scattered through the forests.

The maples grow upon a different plan from most American trees. The fruit trees push up to a certain height and then form a clustered top. Nut-bearing trees grow irregularly. Pines and furs follow a general roseate plan. But the maples shoot up a single main stalk that grows continuously to the very highest point of the tree, except when it has been injured. This excurrent form has two branches growing, one on each side of the trunk; then another pair above them in a somewhat different position, so that the tree is constantly balanced. So strong is the tendency to this manner of growth, that even when the terminal bud has been destroyed by accident, a new sprout growing out of the side near the top takes its place and grows as the main axis nearly as continuously as though it had been the original shoot. Yet the tree is weakened by the accident, and in later years a crack often forms where this sprout starts, so letting in water and beginning the process of decay.

The rapidity of growth of the maples, particularly the white maple (*Acer dasycarpum*, or sometimes called *saccharinum*), renders them peculiarly fitted for shade trees. The white maple frequently becomes a large tree in about fifteen years. Yet the more permanent forms, and those which furnish the most beautiful trees, are found among the sugar maples (*Acer saccharinum*, called *saccharum* by those who name the white maple *saccharinum*). Besides, the foliage of the rock maple is by far more dense. They live from a hundred to a hundred and fifty years, and become a thick trunk with gnarled or knotted limbs. All the maples have sugar in the sap.

Species. The soft or white maple ranges from the New Eng-

land coast to the far West. It loves a moist soil. Its flowers have a greenish tint, and precede the leaves.

The red or swamp maple (*Acer rubrum*) is found mainly in the East. It avoids dry and rocky soils and frequently grows where its roots are covered with water a large part of the year. Its flowers are red.

The sugar maple is the principal source of maple sugar and abounds in New England. It is a tree of rather slow growth, and it flourishes where the winters are intensely cold. Its flowers are slightly greenish when they first appear, but as they mature they become distinctly yellow, and hang in beautiful pendant clusters.

The striped maple (*Acer Pennsylvanicum*) belongs to New England. It is a very small tree, rarely exceeding twenty feet in height, and it is only a few inches in diameter. Its bark is striped green and black.

The mountain maple (*Acer spicatum*) is still smaller, little more than a bush.

Timber. The wood of the white and red maples is soft for a hard wood, and this limits the uses to which it can be put. There is no marked difference between the two except that the red is somewhat darker in color than the white, especially in old growth hard wood, and has some tendency to curl. Soft maple has been much used by the cabinet maker, and selected white maple finished to show the grain makes fine sideboards and chamber sets. Quarter sawed and slit into narrow strips, soft maple makes good hard wood floors. It seldom splinters, and it lasts well, though it darkens with age. So this maple wood is used for making light machinery, as farming tools, because it holds nails and screws well, and does not crush when parts are held crowded together by bolts.

Rock maple timber is hard and dense, and it is used where great strength is required. Its only objection is its weight, for it is very heavy. Besides, its fibres hold firmly so that great patience is required to work it into shape. When the wood appears to be covered with minute dots, it is called bird's eye maple, and it is exceedingly beautiful; and these rare pieces are much sought or fine cabinet work and for the interior decorations of cars and private rooms.

Curly maple is commonly a variety of rock maple, though occasionally a trunk of red maple is found to be curled. In these trees, for some unexplained reason, the fibres are curled and twisted in all directions. This adds to the value of the timber, though it makes it very difficult to work. It is sawed thin, and then worked by hand, requiring great patience and much skill. When finished and polished, it is exceedingly beautiful. It is used for the inside of cars, and for some elegant dining rooms.

III. *The Oak Family* (*Quercus*). This family is widespread, different species being found all the way from Canada to the Isthmus. Most species grow to stately trees, some species being very long lived, occasionally one attaining an immense size. Two or three are little more than bushes, as the scrub oak. Oak leaves are large and shiny and they are sometimes divided into leaflets nearly to the midvein, as in the red oak (*Quercus rubra*). The foliage is abundant, and the oaks furnish a thick shade, not quite so dense as a rock maple produces. The terminal bud persists. This gives the tree a general spherical outline, particularly when the tree grows in an open place.

Oak blossoms appear very soon after the leaves, while they are yet small, and the staminate are distinct from the pistillate, though both grow upon the same tree, and usually upon the same branches. The sterile blossoms grow as long, scaly tassels near the end of the small twigs, and the stamens are coveyed with thin scales until the pollen is ripe. Then the scales turn back and expose the stamens so that the pollen is discharged in great abundance and carried by the wind to the pistillate blossoms. These are placed a little further back on the twig and closely resemble buds in appearance, though they are usually of a different color. Really the pistil is a compressed ovary from which a short style arises. The ovary carries a number of minute ovules, one of which develops while the others are compressed. The fruit is a single acorn held in a scaly cup. In most species, this is shallow and the acorn drops out as soon as ripe, but in the burr oak (*Quercus obtusiloba*) the cup nearly covers the acorn and both fall together.

Species. The white oak (*Quercus alba*) is the most widely distributed American oak, being found in all sections of the country east of the Rocky Mountains. But it must be remembered that the white oak of the interior is not exactly the same tree as that of the East. It is probably the same species, and the difference which is usually considered as making only a variety is largely, perhaps wholly, due to differences in environment. White oak wood is hard and tough, of a light color, the sap wood being a distinct pearly white. The tree is very long lived, and many old trees growing in the open are said to have been six feet or more through. Such a tree must have been at least three centuries in growing, quite likely even five, but those old trees have nearly all disappeared. Rarely can a white oak eighteen inches in diameter now be found. The wood of these old trees was too hard and tough for use, actually breaking the teeth of the saws when an attempt was made to cut them into lumber, and the only way to split one was by using a charge of gunpowder. But smaller trees split readily, and the heart

wood furnishes a tough material for small tools, as ax and hammer handles, canes and goad sticks. The early settlers used it rived by the frow for staves for butter firkins and piggins.

The red oak is the most rapid grower of the family and it forms a large spreading tree rather more conical in shape than the white oak. The leaves are large, the ends of the leaflets are more rounded, and the leaves drop off in the fall, while the leaves of the white oak remain on during the winter to be pushed off by the new leaves in the spring, except when torn off by very high winds. The wood is rather soft, splits readily, has very large pores, and is full of sap that very rarely dries out. Even old timber shows the sap when burned. The heart wood is red.

The black oak (*Quercus nigra*) has a rich yellow or orange inner bark and the wood is very dark. It is a gnarled and scrubby tree, rather rare in the East but abundant in the central region.

Famous oaks. Only a single oak has gained any special notoriety in this country, the Charter Oak, at Hartford, Conn. When Gov. Andros, carrying out his general plan for the destruction of the chartered rights of the colonies, demanded the Connecticut charter from the Legislature, in 1862, Capt. Joseph Wadsworth blew out the lights in the hall where the Legislature was assembled, seized the precious charter and hurried away. He, or some of his associates, thrust it into the hollow of an oak, then already a very old tree, where it reposed in safety as long as there was any danger of its recall. So this old oak became famous as the preserver of the liberties of the Connecticut colony.

There are two oaks in England that antedate history, so that they must be of very great age. One is the Newland oak, in Gloucestershire, known for centuries as "the great oak." Five feet from the ground its circumference is over forty-seven feet, and it does not seem to have increased in circumference more than one or two inches in the last two centuries. Though it is hollow at the butt, it maintains its vigor. The other is the Cowthorpe oak, near Weatherly in Yorkshire. This is thirty-eight and a half feet in circumference and is not known to be hollow. Both of these oaks were connected with Druidical worship and retain much of their former reverence.

Closely related to the oak, but of a different family, are the nut trees. Only two of these are sufficiently common to require notice here—the hickory and the chestnut—and both of these grow more or less abundantly in all regions of the country.

The hickory (*Cara sulcata, etc.*), which has several varieties, has the widest range of the nut trees. The several varieties differ mainly in the size and flavor of the fruit. Some of the nuts are

small and bitter while others are large, the largest of all being found in Ohio, where it bears the local name of shellbark. The nut itself is protected by an outside shell which is bitter and disagreeable, but which drops apart and allows the nut to fall out as soon as touched by the frost. The walnut (*Juglans nigra*) is very much like the hickory.

The chestnut (*Castanea*), is a rather swift-growing tree, tall and slender; and there are several varieties that differ but little save in the size of fruit. In this fruit the nuts, usually three in number, are enclosed in a thick prickly burr. This thoroughly protects the growing nut, but the early frost cracks it and the nuts fall out.

The wood of nut-bearing trees is generally hard and tough, often very dense. So hickory, the toughest of all, furnishes the best timber for tool handles and for the spokes of wheels. These two uses consume all the straight-grained hickory in the market. Walnut is dark colored, shows the marks of growth early, and takes a high polish. This makes it valuable to the cabinet maker. Chestnut is soft and rather light and shows the difference between the two parts of the year's growth very clearly. Quarter sawed, it makes a beautiful wood for inside furnishings, particularly the wainscoting of public buildings.

IV. *The Birch Family* (*Betula*). Forests made up of birches are marked by the contrast between their appearance in summer and in winter. Densely covered with the foliage of light green in the summer, they contrast strongly with the bare rocky cliffs against which they seem to be set as a background. But in winter their bare tops show dark and gloomy, while their shining trunks blend with the snow which covers their roots, the two uniting into a single landscape.

The outer bark of the birches separates easily from the inner and consists of a mass of tough fibres that run around the tree. In some it peels off easily in long strips, leaving the inner bark exposed. Its color is so prominent a feature as to furnish the names of the species. Unlike most trees the young sapling bears little resemblance to the old trees, their parents. Only the most careful examination will show the species in the young tree. Thus the white birch is distinctly red until it gets to be about three inches in diameter, when the baby bark splits and peels off. The young black birch has a smooth and shining bark, distinctly brown in color, while the mature tree is almost black and rough.

The flowers of the birches and their near relatives, the alders, are long spikes or catkins, the pistillate flowers being separate from the seminate. The birches put forth their yellow flowers along with the leaves, but in the speckled alders they precede, often

coming in winter. The sterile catkins are long and slender, the flowers, in clusters of three each, standing so loose upon the stalk that they droop, while the pistillate flowers stand erect in much smaller catkins

The fruit of the birches is a small flattened nut with wings. It is produced by two cells of the ovary growing together, while all the ovules but one are suppressed. The fruit is generally single, but in the yellow birch several seeds are packed together in the central part of a ripened cluster, whose general appearance resembles a cone. This frequently falls without dropping the seeds, so that the yellow birch often grows in clumps, while the other birches germinate singly, like the oaks and nut trees. These clumps are so closely crowded as to resemble single trees.

Species. The birch that covers the most extended area in North America is the yellow or silver birch (*Betula lutea*). But rarely is it found in any great abundance, while other species make whole forests. It is distinctly a forest tree, that is marked by the color of its outer bark and by glistening fringes hanging from it, that shine in the sunlight like silver. It often grows to eighty feet in height and has a thick trunk. The young sapling can be best recognized from the leaves, which are ovate, distinctly pointed, sharply serrate, with an outline that curves in toward the point. Viewed from beneath, the midvein and most of the minor veins appear as prominent ridges, while the stem is hairy.

The black birch (*Betula lenta*) grows to a large tree that often has no limb lower than thirty feet from the ground. The leaves are distinctly oval, with points that bend to one side, and the veins are not prominent. The outer bark is rough. The most marked feature of the tree is the sweet spicy odor given off by the inner bark, which contains oil of winter-green. Indeed, this bark is now the principal source of this oil.

The white birch (*Betula propulifolia*) and the canoe birch (*Betula papyrifera*) so closely resemble each other as to be frequently mistaken for the same species. They grow in the same sections and their special features are much alike. The canoe birch is the larger tree and the markings on the outer bark are much the coarser, while it strips off far more readily. Still, there is no easy method of distinguishing the two species but by the leaves. White birch leaves from the mature tree are triangular, with a point considerably extended. Each side is concave, and there is a smaller curve between each pair of veins. This gives the margin a decidedly curved appearance. All except a small part near the stem is toothed, and the leaf has a general delicate appearance. But the leaf of the canoe birch is much shorter and coarser, is rounded or

ovate, with no point, and the veins stand out very prominently on the under side. The whole appearance is the opposite of delicate.

A small birch grows profusely in certain sections, as New England, which has marked features of its own. Its popular name is gray birch. It stands in clumps and grows to a height of about twenty feet and is only a few inches in diameter. It is very pliant, so that youngsters climb nearly to its top, bend it down almost to the ground and "ride it," finding it delightful sport. When a clump of these birches is cut away, new shoots start from nearly every stump and a new clump soon stands in the place of the first.

Birch timber. Birch is not a valuable timber wood. Yet such birches as furnish logs of some size free from knots and gnarls find a ready use. Black birch is the best, because it is rather hard. It is a rose tinted and takes a high polish. So, it is suited for the cabinet-maker, who makes beautiful sideboards and other articles, finishing them in the natural wood, or with a little darker stain added.

The wood of the white and of the canoe birch is so nearly alike that it is sold for the same. It is soft and easily worked; yet it does well for floors, if kept carefully dressed. But the most important use of this wood is for clothes-pins and spools. Clothes-pins are made in enormous quantities by special machinery. The lumber is first sawed into boards of the exact thickness of a clothes-pin; then the boards are ripped up into square sticks four feet long. Then these are put into the finishing machine endwise. The machine cuts the sticks into lengths suited for a single clothes-pin and turns it almost at a stroke into the shape of the finished pin. As the block falls out, it is carried by an endless apron to another machine where it drops into a hopper. This allows the blocks to drop out one at a time, but only with the head turned in one direction. A pair of jaws then seizes the forms and feeds them up to two saws, which work at a slight angle to one another, and cut the slot which allows the pin to cover the article on the clothes-line.

Spools are made in much the same way, except that the sticks are turned round before they are cut up. Then the pieces are cut into blocks just the length required for two spools, and the hole is bored through them. Next the two are turned by a single stroke of the machine, and the ends are polished. Afterwards they are sawed apart and fall out of the machine. So spools of thread have one end polished and the other roughly sawed.

The number of clothes-pins and of spools used is almost incredible, being certainly far up in the millions. Yet it is calculated that these industries do not use up the birch wood any faster than it grows.

Rocks and Topography of Manhattan.

By George K. Gombarts, Instructor, New York City.

MANHATTAN ISLAND, old New York City, is irregular in outline, resembling somewhat a trapezium. The length is about thirteen miles, the width about two, narrowing down at the northern end to three-quarters of a mile.

Topographically it can roughly be divided into three sections, not very clearly defined. The first includes the territory south of Murray Hill, or 34th Street; the second, the region south of Mount Morris Park, or 120th Street; and the third, the district below Spuyten Duyvil.

Not long ago the island presented almost every possible form of land configuration. Along its shores were found swamps, salt marshes, mud flats and hilly slopes running vertically down into the water. Inland we now find unmistakable evidences of swamps, in the wholesale leather district, about Gold and Frankfort Streets; the old Collect Pond, long filled in and now occupied by the Tombs and the Criminal Court building. But of the hills of drift material, boulders, gravel, sand and earth, such as still stand at 67th Street and Third Avenue, and which are common about Prospect Park, Brooklyn, little remains. Other hills of more enduring material, as Murray Hill, at 34th Street (a gneiss formation), the wooded hills of Central Park and Mount Morris Park, still stand as reminders of the past.

In the lower end business requirements, and the northward movement of population in the upward part, have caused the leveling of most of the once numerous hills of the island. The same causes have also reclaimed the marshy shores of our island and increased its area by the addition of hundreds of acres of made-land by a filling in process, especially along the eastern, southern and western shores. Battery Park, the territory east of Avenue C and west of Greenwich Avenue, is all made-land. The process is going on along the Harlem River at the present time. Between the many hills small streams of all sizes found their way east or west to the rivers, or into the small ponds and lakes so numerous in the Harlem section of the island. Such were "Minetta Water," on the lower west side, and the Great Lake in Central Park.

North of 59th Street a ridge of rock runs parallel to the North River, in the hollows of which there existed till within a few years "Shanty Town," the haunt of the squatter and his inseparable goat. Here the rock has been blasted away, but at places the vertical wall

of rock clearly shows the original height of the ridge. Such cuts can be seen on 110th Street, west of Columbus Avenue, 116th Street and Fifth Avenue, 117th Street, near Madison Avenue, and Duffy's Hill, at 102nd Street and Lexington Avenue.

This ridge of rock, paralleling the Hudson on the west and forming on the east an irregular crescent, can be traced from 90th Street and Third Avenue northwestward, sloping gradually down to Manhattan Valley at 130th Street on the north, and ending abruptly on the east in Morningside Park. Beyond, to the east, the filled-in Harlem mud-flats are interrupted only by the jagged rock of Mount Morris Park.

Beyond the "Valley" the whole, long, narrow upper part is elevated and traversed by the rocky backbone, which rises continually until Fort George is reached. Here it bends west to Kingsbridge, and thence north to Spuyten Duyvil. Such, in brief, is the topography of Manhattan.

The underlying or bed-rock that forms the ridge or backbone of New York is gneiss, which is an igneous rock, consisting of mica, quartz and feldspar, the same constituents as found in granite. In gneiss they are arranged in layers, while in granite they are indiscriminately mixed. Above 59th Street the rock is exposed; below that point only recently has bed-rock been struck, as the building of gigantic "sky-scrapers" necessitates rock foundations. In the lower or business section of the city beds of sand, clay and boulders are often encountered before solid rock is reached. Mica schist, hornblendic gneiss and hornblende schist, together with a small percentage of limestone, are found on the island.

Here and there running through gneiss folds are found thin seams of granite, readily distinguished by their light coloring. Along Cathedral Parkway, Spuyten Duyvil Creek, the Bluffs along the East River, between 59th and 86th Streets, and along the Speedway, such veins of granite are quite frequent. Mica schist, the same as gneiss in composition, but variable in the proportion of the constituent minerals, is softer than gneiss and is disintegrated more rapidly. This peculiarity often compels contractors to blast off the soft, yielding surface rock in order to reach the hard rock below.

At one time a variety of granite was quarried between Tenth and Eleventh Avenues, between 44th and 55th Streets. A very good outcrop of granite may be seen on Central Park West at the entrance to the driveway at 106th Street. A dolomitic limestone is found at Kingsbridge and along the Harlem Ship Canal, where, in Marble Hill, it attains a height of fifty feet. It is also found in Dyckman's Meadows, just beyond Fort George. This dolomite has been called "Kingsbridge marble."

Elementary Study of the Nervous System.

By M. A. Bigelow, Instructor in Biology, Teachers' College, Columbia University.

THERE are comparatively few important facts relating to the structure and activities of this exceedingly complex system of organs, which it is reasonable to suppose may be clearly comprehended by pupils in even the last grades of a grammar school. A careful consideration of the practical and educational value of the subject matter concerning the anatomy and physiology of the nervous organs fails to give justification for the common method of involving in an elementary study a large amount of detailed description. Why should a grammar school pupil study long, meaningless descriptions of the cerebrum, cerebellum, medulla oblongata, pia mater, and the long series of cranial nerves from olfactory to hypoglossal? But this is just what the pupils do study in many current text-books. There is little reason why many of these should be even mentioned by their names, much less given a description, in any grade below the high school, and it is even doubtful whether they should have any place below college. In elementary schools, structure of organs should be taught only as a basis for later study of their activities, but the physiology of the nervous organs is so intricate that knowledge of their structure will do little to explain nervous functions to the young beginner who is led into this field where more advanced students find difficulty. With the exception of some general facts, knowledge of the structure of the nervous system is for the elementary pupil practically useless, for from such facts of structure it is not possible to lead to an understanding of functional activity upon which practicable hygienic advice may be scientifically based.

So far as it is possible to teach hygiene in elementary schools, there are very few principles or rules which have any direct practical application to the nervous organs, and even these few are made intelligible by the facts of common observation. The most useful hygiene relating to the nervous system has its basis in the physiology of the nutritive organs, healthfulness of which is so closely associated with the normal nutrition and activity of the nervous organs. Thus hygienic advice regarding sleep, rest, nervous overwork, etc., is not made intelligible to the elementary pupil by memorizing a mass of facts concerning the anatomy and physiology of various parts of the nervous system; but such rules may be clearly understood and presented from the standpoint of the simple fact that the nervous organs control the muscles and organs of general nutrition, and the normal activity of these reacts upon the healthfulness of the nervous system. Faithful application of the scien-

tific hygienic principles to the muscular and general nutritive organs would leave little demand for special rules for direct care of the nervous system; and an understanding of the structure and normal functions of these organs, so far as the facts can be used in giving a foundation for intelligible and practical hygiene, is far more important than any hygienic advice which may be founded directly upon the special anatomy and physiology of the nervous system. Clearly, study of the anatomy and physiology of the nervous organs cannot be well defended on the ground of its intimate relation to practical hygiene—the greatest argument in favor of elementary study of the structure and functions of most other organs. The important hygiene of the nervous system which touches upon the domain of psychology demands a basis in the facts of anatomy and physiology; but it is obvious that this does not militate against the position here taken with regard to the most elementary work.

The conclusion drawn from this examination of the practical and pedagogical value of elementary study of the nervous system is that work on its structure and physiology finds little justification in possible correlation with other important topics within or without the field of physiology or hygiene; and therefore the teaching relating to these organs should be decidedly limited, so far as elementary schools are concerned.

The following outline of a lesson plan will serve to indicate the nature of the limited work on the nervous system which in the writer's opinion may deserve a place in one of the last two grades of a grammar school. But the vastly more important study of other systems of organs should first be well done, even though the work on the nervous organs must be limited to the incidental references which are necessarily involved in the lessons on the muscular and nutritive systems:

Outline of Lessons on the Nervous System.

1. Emphasize the work of the nervous organs as a means by which all the other organs are regulated, coördinated aud directed, and as a medium for communication with the world external to the body. Illustrate coördinating action by reference to the easily observed effects of violent exercise of the muscular organs upon such processes as breathing, beat of the heart and pulse, excretion through the skin and heart regulation.

Emphasize the dependence of the nervous system upon the nutritive organs.

2. Point out by reference to skeleton, charts, and especially by reference to the pupil's own body, the position of the brain and spinal cord in relation to the other organs of the body.

3. General structure of the brain.

A sheep's brain permanently preserved in a 4 per cent. solution of formaldehyde may be used to illustrate the general form and appearance of the organ. Good models and charts are useful. The attention of the pupils should be called to the general form of the brain, its protective envelopes (do not name these), the division into right and left halves, the origin of some of the larger nerves, and the blood vessels which are important for the nutrition of the brain. If time and local conditions permit, the pupils may make outline sketches of the brain as seen from above, from below, and from the side. Such practical study gives training in observing, stimulates interest, and gives an impression of the form and appearance of the brain such as can not be acquired from pages of printed descriptions. The names of the four or five chief parts of the brain may be labelled on the drawings. Some simple description in a text-book should be read, but not prepared for either oral or written recitation.

In a general way, without using technical names, call attention to the distribution of nerves from the brain to the nose, eyes, eye-muscles, ear, face and tongue.

An elementary study of the internal structure of the brain is necessarily very limited. A brain hardened in formaldehyde may be cut into transverse slices about one-half inch thick, which may be permanently preserved. Examination of these will give the pupils a good idea of the brain as an organ with thick walls of nervous substance and relatively small cavities. A few minutes devoted to such a series of sections will be full of interest.

4. General structure of the spinal cord and distribution of its nerves.

A spinal cord of a sheep (removed from the backbone and permanently preserved in formaldehyde) may be examined along with any available charts and models to illustrate the general form of the cord. Point out surrounding protective membranes, blood vessels which supply the cord, and the pairs of spinal nerves. Transverse sections (cut with a razor from a cord hardened in formaldehyde) may be examined along with a chart or drawing, and the division of the cord into right and left halves and positions of white and gray matter may be demonstrated. Outline drawings may be made. This brief examination of a transverse section is of value from the standpoint of interest and practice in observing and recording results in sketches, but the knowledge to be acquired in this exercise can not be of much significance to elementary pupils.

The general distribution of nerves from the spinal cord to the limbs and other organs of the body may be shown on a dissected

frog, which may be permanently preserved in formaldehyde. Emphasize the statement that minute branches of nerves connect all parts of the trunk and limbs with the spinal cord. (Refer to charts and figures in text-books). Have the pupils touch various parts of their bodies with a needle point in order to determine the distribution of the endings of nerves in the skin.

Minute structure of nervous tissue is a topic too difficult for the young beginner, but for the sake of interest a compound microscope may be used for a glimpse at some prepared slides, such as preparations showing nerve cells and fibres.

5. Functions of the brain and spinal cord. In the writer's opinion experiments upon decapitated frogs, by which advanced students are taught the fundamental facts regarding the functions of nerves, spinal cord and brain, should not be performed before classes of pupils in elementary schools. However, there are important points in some of the simple experiments which may be briefly described in order to teach some important general facts. The most important are as follows: Cerebrum destroyed by disease or operation results in loss of intelligent and voluntary action; cerebellum removed results in loss of muscle coördinating power; injury to spinal bulb interferes with contractions of heart and the muscles concerned in breathing movements; contraction of muscle is produced by stimulating the nerve, which shows how nerves control muscles; cutting the nerves of a limb results in loss of sensation and power of causing the muscles to contract, which proves that the nerve centers must lie in the central nervous organs. All these are mentioned in the elementary text-books and are merely mentioned here in order to call attention to them as illustrating important functions.

Reflex action (muscle contraction without will) is illustrated by the involuntary movement resulting from unexpected sudden contact with a hot piece of metal or by the closing of the eye-lids when a blow is threatened. Voluntary action is illustrated by placing a finger on a piece of metal which is slowly heated until by an effort of will the finger is withdrawn from the unbearable heat.

The pupils should be instructed to experiment upon themselves at home and make a record of the parts of their bodies which they can move voluntarily, and also those whose movements can not be controlled by the will.

Many suggestions bearing upon topics in this outline are to be found in elementary text-books of physiology by Hall, Martin, Colton, Blaisdell and others, but the elementary physiology by the first-named author is especially recommended for use in the elaboration of the foregoing lesson plans.

The Leaves of Our Common Trees.

By Austin C. Apgar, Professor of Botany, State Normal School, Trenton, N. J.

IN looking over any landscape or taking in any views of nature did it ever occur to you how much of the scene is *just leaves?* The ground everywhere is carpeted by the leaves of grasses and other plants; the trees show little but leaves. Then what more fertile topic could be chosen for nature lessons than the foliage?

Ask your pupils to tell you the use of leaves to plants, and then require them to gather the leaves of a score of different kinds of plants, cautioning them to be careful in each case to select the *whole leaf and nothing but the leaf*, and you will most forcibly discover that ignorance in regard to leaves is startling enough to warrant many lessons on the subject.

We are all willing to use the expression "a three-leaved clover" when the thing we are endeavoring to talk about is in reality a three bladed clover *leaf*; which merely goes to show that we rarely think or know just how much or little it is that constitutes a full leaf. Generally speaking, the trees of our parks, lanes and yards have but one blade to each leaf, but of course there are many exceptions. The horse chestnut (9) has seven blades, the common locust (13) nine to seventeen, the honey locust (27) twenty to over two hundred, while the silk tree (26) has from five hundred to thirteen hundred. Our trees thus range from one blade to over a thousand blades to a leaf.

In order to determine just what constitutes the whole leaf of any tree the best method is to take for examination a twig which has grown to some length during the year. This new growth will be seen to have brighter colored and smoother bark than that of the older twigs. The young twigs will have the leaves at the points or nodes of the stem. At the axil or angle where the leaf joins the twig there will generally be found a bud, an undeveloped twig of a succeeding year. The bud and leaf marks a node of the stem. More than half of our trees will be found to have but one bud and leaf at each joint, and leaves thus arranged are said to be alternate. Many, such as the maple (28-37), horse chestnut (9), ash, and dogwood (2) will have two instead of one, on opposite sides, at the node, forming opposite leaved trees. Three of our trees, although usually bearing opposite leaves, will on vigorous growths have three leaves at a node, thus giving the tree whorled leaves. These are the Indian bean (3), the Paulowina and the juniper (21). Therefore, all that part of a plant which has a bud at its base is a leaf.

Our trees can very readily be divided into two groups, the

BROAD-LEAVED TREES.

1. Swamp Magnolia. 2. Dogwood. 3. Indian Bean.
4. Sweet Gum. 5. Buttonwood. 6. Sassafras.
7. White Birch. 8. Cottonwood. 9. Horse-chestnut.
10. Chestnut. 11. White Elm. 12. Gingko. 13. Common Locust.

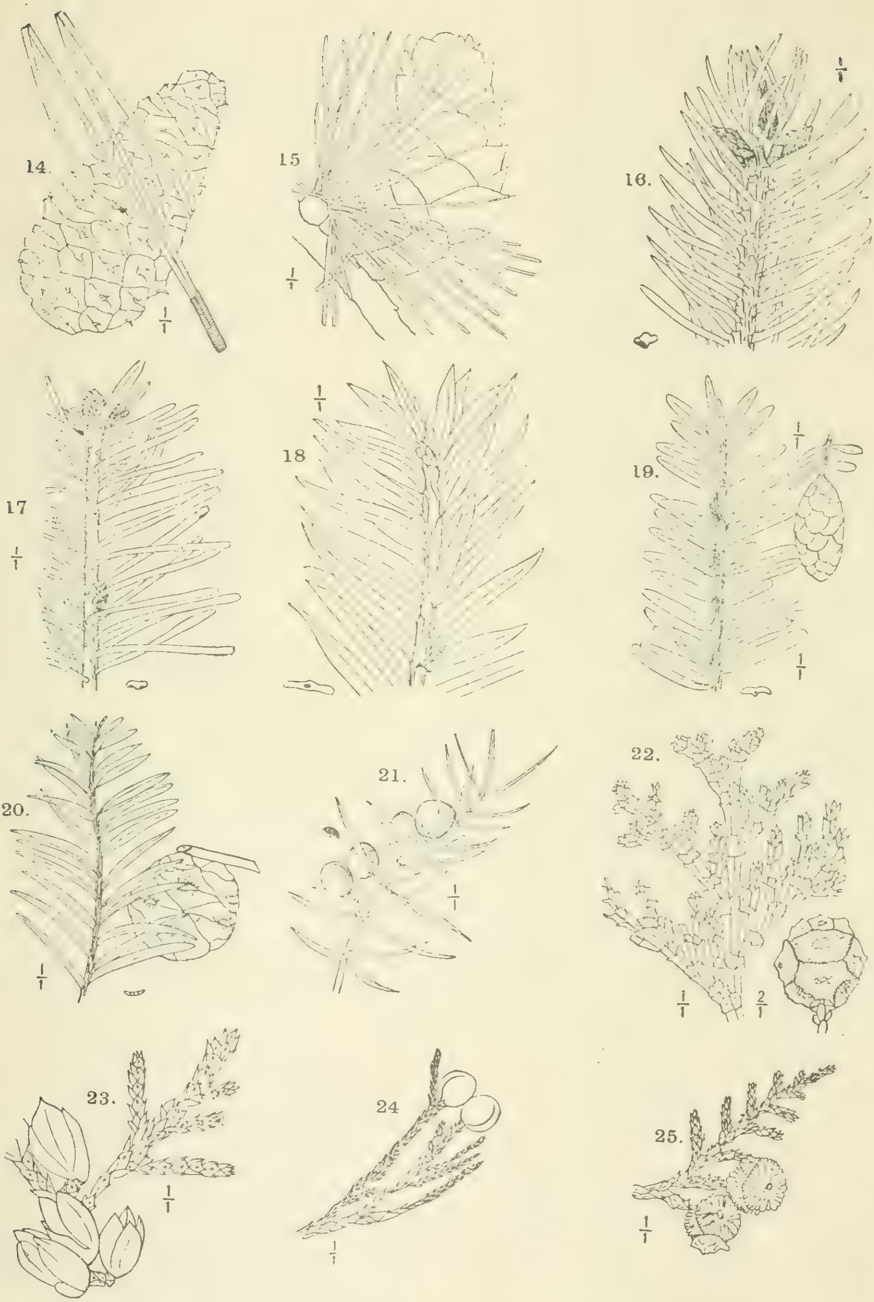
Illustrations from "Trees of the Northern U. S." Courtesy American Book Co.

broad-leaved trees (1–13), and the narrow-leaved trees (14–25). The broad-leaved trees are usually deciduous, though the great laurel and one of the magnolias are evergreen. The narrow-leaved trees are generally evergreen, though the bald cypress (20) and the larch (15) are deciduous.

One of the most distinctive differences between the blades of leaves is that of the veining. There is but one broad-leaved tree with parallel veining, the gingko (12). All others have netted veining, and the framework consists of a mid-rib, other more or less heavy ribs and a fine network of veins between them. If these heavier ribs extend in a regular way from different portions of the mid-rib, we have feather-veined leaves (1, 2, 6, 7, 10 and 11). If two or more of the heaviest ribs extend from the base of the mid-rib we have radiate-veined leaves (3, 4 and 5). There is one variety of feather-veining characteristic of birch (7), beech, chestnut (10) and elm (12) worthy of note. These examples have the branches extending from the mid-rib entirely to the margin in a very regular way, and are said to be straight-veined. The magnolia (1), sassafras (6) and cherry leaves are feather-veined without being straight-veined.

Another interesting difference between leaf blades is found in the margins. Some blades, such as the quince, magnolia (1), persimmon, dogwood (2) and common locust (13) have entire margins, but a much larger number, such as the chestnut (10), elm (11), birch (7), horse-chestnut (9), etc., have saw-like edges (serrate); still others, such as the maple (28–37), tulip tree, many of the oaks (41–47), sweet gum (4) and buttonwood (5) have a few large notches, forming lobes. The older growths of the mulberries show leaves with serrate margins, while on the rapid growing shoots there are deeply divided lobes. The sassafras (6) illustrates how the same plant may have entire leaves as well as lobed ones. This lobing when it reaches its final stage forms compound leaves. A good example of the irregular compounding of leaves is shown in the figure of the honey locust (27). The piece of twig has six alternate leaves. The first and second are simply once primate (feather-like compounding of leaves); the third and fourth are irregularly once to twice primate; while the fifth and sixth are fully twice primate, the last one having over a hundred and fifty blades. The silk tree (26) is regularly twice primate with about twelve hundred blades.

In the narrow-leaved trees (14-25) the blades have almost no notched margins and no compound forms. Each blade, no matter how small (less than a sixteenth of an inch long), in the red cedar (24) forms a complete leaf. These narrow leaves are needle-like on the pine (14), larch (15) and cedar of Lebanon, four-sided on the



NARROW-LEAVED TREES.

14. Yellow Pine.	15. European Larch.	16. Norway Spruce.
17. Balsam Fir.	18. Yew.	19. Hemlock.
20. Bald Cypress.	21. Juniper.	22. Japan Arbor-vitæ (Retinospora).
23. American Arbor-vitæ.	24. Red Cedar.	25. White Cedar.

Illustrations from "Trees of the Northern U. S." Courtesy American Book Co.

SILK TREE.

spruce (16), linear and flat on the fir (17), hemlock (19), yen (18) juniper (21) and bald cypress (20), and scale-like on the red cedar (24), white cedar (25), most of the cypresses and arbor vitæ (22 and 23).

The needle-shaped leaves can be readily divided into their proper groups; the pines (14) with two to five evergreen leaves in a sheath, the larches (15) with over eight soft, deciduous leaves in a cluster, and the eastern or Lebanon cedars also bear over eight stiff evergreen leaves in a cluster. The flat linear leaved trees can also be easily divided into groups; the firs (17) have sessile evergreen leaves spirally arranged around the stem and usually have a disklike base fastened to a smooth twig; the juniper (21) has sessile, sharp-pointed leaves either opposite each other or, usually, in whorls of trees; the bald cypress (20) has soft, deciduous leaves; the yen (18) and the hemlock (19) have short-stalked evergreen leaves much alike in a general way, but the yen leaves are acute-pointed and the hemlock blunt-pointed. The scale-leaved trees need the fruit in order to make it possible to determine their names. The red cedar (24) has small, purplish berries; the true arbor vitæ (23) have small elongated cones with lapping scales; while the cypresses, which include many so-called arbor vitæ (32), and the white cedar (25) have rounded cones with scales joining each other at their edges.

The study of the foliage of trees in order to enable us to know the genus to which a specimen belongs, *i. e.*, whether it is an elm, maple, birch, dogwood, oak, pine, spruce or fir, is only a beginning in the study of trees. In a very short time we will

HONEY LOCUST.

wish to know how to determine the different species of a genus from each other.

A few of the groups of trees are very common in cultivation because of their great beauty of form and foliage and their hardiness under the usual poor conditions in our towns and cities. The separation of these into their species by the examination of leaf forms becomes a very interesting study.

The commonest of these groups is the maples (28-37). Of these the most frequent in cultivation are the sugar (34), the Norway (31), the white (35) and the red (32). The leaves of the sugar and the Norway are much alike in form and margin, but the Norway (31) is distinguished by having broader leaves in comparison to their length, by the underside being nearly as green as the upper, and by having milky juice. The sugar (34) has somewhat thicker leaves, a whitened underside and watery juice.

MAPLES.
28, 29, 30 and 37. Dwarf Japan.
31. Norway.
32. Red.
33 Sycamore.
34 Sugar.
35. Silver or White.
36. Ash leaved or Box elder.

The white (35) and the red (32) are again quite similar. They differ from the sugar and the Norway in having more small notches along the lobes. Both of these have a whitened underside, but the white or silver maple, as it is often called, receives its name from the fact that the underside is the whitest of that of any of the maples. A better method of telling them apart is by knowing that the notches between the lobes of the white maple (35) are deeper, broader and almost rounded at the end, while the notches are acute in the red maple (32). Another plan, and the best of all, is to know that the fine twigs of the white maple have a tendency to droop, and thus form a weeping tree. It is the only one of our maples which shows this peculiarity. Wier's cut leaved form is a very beautiful weeping tree. The sycamore

maple (33) is also often found in cultivation. On this tree the lobes are like those of the red and the white in leaving many small notches along the margins of the lobes, but the lobes themselves are very blunt and the leaves are much thicker in texture than those of the other species. There is one species with compound leaves. The ash-leaved maple is box-elder (36). This is proven to be a maple by its two-winged fruit. These varieties so far given are tall trees, but in our parks and private grounds there are many beautiful, small, almost bush-like growths, with the opposite, lobed leaves and the winged fruits of maples. Of these the most common and most beautiful are the Japan species (28, 29, 30 and 37), which in some of their varieties have their leaves cut into the most delicate fringes, and in others are so brilliantly red in the spring as to rival the roses in color.

A more difficult group of trees to study is that of the oaks (38–47). These are rendered difficult to study by the great number of species in cultivation, and also by the numbers of intermediate forms or hybrids.

OAKS.

38. Swamp White. 39. Chestnut. 40. Shingle 41. Pin. 42. Scarlet. 43. Red. 44. Black. 45. Bur. 46. White. 47. Post.

The alternate, thick, feather-veined leaves, hard wood, and the acorn fruit separate the oaks from all other trees. Our northern oaks can be readily divided into four groups by the leaf margins.

1. Those with entire margins, the single oak (40) and the willow oak. The single oak leaves are about a third as wide as long, while those of the willow oak are usually less than a fourth as wide as long.

2. The chestnut tree (38-39) with waved or regularly notched margins and straight veins. The one having coarsest notches to its leaves is the swamp white (38) with four to nine rounded notches on a side; the chestnut oak proper (39) has eight to sixteen rounded

notches on a side; and the yellow chestnut with leaves most like those of the true chestnut tree has five to twelve acute notches on a side. The three chestnut oaks given are large trees. There is a scrub chestnut oak usually growing but from two to five feet high.

3. The *white oaks* (45–47), having deeply lobed margin with rounded projections free from bristles. The white oak proper (46) has the underside of the leaves smooth and of a light color, while the others of the group have more or less numerous short hairs covering the lower side, even when mature. The bur oak (45) receives its name from the fringed, bur-like margin to its acorn cup. One of the European oaks, often cultivated, has such a fringed cup, the Turkey oak, but the bur oak, like the white oak, has scaly, light-gray bark, while the Turkey oak has furrowed and ridged, but not scaly, bark. The post oak (47) has fewer lobed leaves with brownish hairs on the under side.

The *black oaks* (41–44), having deeply lobed leaves, the lobes ending in acute, bristle tipped points. The pin oak (41) has the smallest and usually most deeply notched leaves, and the underside is generally very smooth except for some hairy tufts at the branching of the veins. This oak receives its name from the great number of short branches it possesses, and is best determined by the dropping of the limbs near the base of the tree. The red oak (43) has larger leaves and the notches are less deep and not so rounded. This tree has much heavier branches and forms a broad, round-topped symmetrical head. The scarlet oak (42) and the black oak (44) have leaves more like the pin oak in the character of the notches in both depth and breadth, and probably need a study of the acorn before they can with certainty be separated. Both the pin and the red oaks have shallow, saucer-shaped caps to their acorns, while the scarlet and black oaks have deep, cup-shaped ones. To separate the scarlet and black oaks with certainty, it is necessary to see the color of the inner bark of the trunk. In the black oak this is a distinct orange, while in the scarlet it is gray, or, at its brightest, a pinkish shade.

Classification of Rocks.

By L. P. Gratacap, Assistant Curator, American Museum of Natural History, New York City.

Character and Structure of Rocks.

ROCKS are the large mineral masses which compose the earth's solid crust. They form the nucleus of the continents, are seen in their mountains, hills, cliffs and quarries. Their structure varies with their origin. If they have been formed as the result of the cooling of melted or plastic masses, they are glassy or crystalline. If they are the consolidated accumulations of sediment, sands gravel, clay marl and calcareous mud, they are massive, compact, granular bodies, not distinctly crystalline, unless after great pressure and some heat, a semi-crystalline structure is developed (metamorphism).

Of the former sorts of rocks, granite, syenite, trap are familiar examples; of the latter, slates, sandstones, limestones and conglomerates.

In a geological sense, though I think the usage could be wisely discredited, a rock is also any mass of stony material, which forms a substantial part of the earth's surface, as marl-beds, clay-pits, sand-banks or gravel ridges. The conception is not readily substantiated by any appeal to our ordinary use of language or our inherited and habitual impressions. Marl-beds, clay-pits, sand-banks and gravel ridges are the result of the disintegration and weathering and decomposition of rocks, and in them all characteristic rock structure has disappeared.

When we examine more intimately the structure of rocks we find that they are either composite or simple mineral masses. They may be made up of one mineral, enormously extended, as garnet rocks, tourmaline rocks, or even, as in the case of limestones and marbles, the common mineral calcite has here attained so great a spatial extension as to become a rock; or else they are made up of a group of minerals almost invariably associated together to make a particular kind of rock, no matter wherever it is found, as granite, which, over the entire world, is composed of mica, quartz and feldspar, though the exact proportion of these several constituents may vary between very wide limits in each locality where granite is found.

A number of terms which are to some extent self-explanatory, have been applied to rocks:

Granitoid: Like granite, granular crystalline.

Micro-Granitic: Fine grained, like granite.

Micro-Crystalline: Minutely crystalline, compact, very fine texture.

Porphyritic: When some constituent mineral appears in conspicuous single crystals through the rock.

Foliated: Showing cleavage planes arranged in plates, like the leaves of a book.

Fluidal: Showing flow lines, where the rock, when in a viscous or lava consistency, has run in certain direction or lines.

Glassy: Like glass in texture.

Vesicular: } With small cavities, holes.

Scoriaceous: } Cells, as in *pumice.*

Amygdaloidæ: With almond shaped cavities, lined or filled with other minerals.

Besides the minerals which represent the typical phase of a rock, there are other associated minerals which have been developed in the rock but which do not enter into its technical character, although quite universally found in the rock. Thus in granite (mica quartz and feldspar) there are often found beryl, tourmaline, apatite, amphibole, garnet, pyrite and other minerals.

THE CHARACTER AND STRUCTURE OF MINERALS.

A mineral is a definite chemical element or a chemical combination of elements. For instance gold, silver, antimony, tellurium, copper, platinum, sulphur, are all simple irreducible elements. They are slso minerals and occur widely over the surface and through the rocks of the earth. Again pyrite, orthoclase, topaz, tourmaline, barite, are all well known minerals but are combinations of the elements, thus pyrite is a *sulphide of iron;* orthoclase, a *silicate of potash and alumina;* topaz, a *silicate of alumina;* tourmaline, a *silicate of alumina iron manganese with boracic acid.*

In structure minerals are amorphious (*not crystallized*) or crystallized, glassy, opaque, transparent, translucent, fibrous, porcellanous, dull, lustrous, earthly, in short, present all the varied aspects of surface and interior which an inspection of the minerals in any cabinet display.

There is therefore an easily understood and easily defined difference between a mineral and a rock. A mineral is an element or a combination of elements, limited in size and occurrence. A rock is a combination of minerals or one mineral so enormously extended as to form a topographical feature in a landscape.

The more common rock-making minerals are quartz, the feldspars (orthoclase, labradonite, albite, oligoclase), the micas (muscovite, biotite, phlogapite), nephelite, andalusite, fibrolite, staurolite, tourmaline, garnet, epidote, chrysolite, hornblende, augite, eustatite, serpentine, talc, calcite, gypsum, fluorite, clay, hematite, magnetite, limonite, water.

Sedimentary or Fragmental and Crystalline.

Rocks may be conveniently separated into sedimentary or fragmental rocks, those which are made up of mineral matter deposited in water, or formed by cementation of broken fragments of other rocks; and crystalline, those in which through some initial plasticity or fluidity, induced by heat, the mineral elements have crystallized, have more or less separated into individuals, and undergone that molecular aggregation, commonly known as crystallization, which is always associated with optical characters.

Sedimentary rocks are familiarly illustrated by the limestones and sandstones, also by the slates and some schists. The sandstones most easily and characteristically meet the definition, being rocks formed by grains cemented together into compact rock masses. Limestones are also granular aggregates, as are also slates, but in the latter case, as in marbles (a kind of limestone), *metamorphism* has induced a semi or entirely crystalline character. By metamorphism is implied the agencies of heat and pressure. (See Lessons of the Quarry).

Crystalline rocks are also readily recognized in the granites, syenites, porphyries, traps, where, by hand or microscopic inspection, the rock is seen to be made up of mineral crystals which respond to optical tests.

The Limestones and Sandstones.

Limestones are practically carbonate of lime, with a slight admixture of foreign material, as clay, quartz, iron oxide and sandy residues of other minerals. They vary greatly in hardness. There are soft and very hard limestones; limestones in which fossil forms can be readily separated, and those so compact, dense and crystalline (marbles) that all traces of animal remains have entirely vanished. An examination of any group of limestones and marbles (see the Jesup Collection of Building Stones, first floor, American Museum National History) shows the wide range of color and texture in limestones. Limestones graduate from the granular, fossiliferous and softer varieties into the hard, brittle and crystalline marbles. Limestones have been laid down in water as calcareous muds, and slowly hardened and consolidated, upon elevation, into rock.

Sandstones are also sedimentary or fragmental rocks, as the slightest inspection will show. The Portland sandstones, Berea grits, from which so many houses in New York are built, reveal at once their clastic nature. Looking over a cut surface of Portland sandstone, the separate grains are seen varying, within small areas, indefinitely in size.

Sandstones have been conveniently separated into four classes,

those in which the grains seem held together by interlocking, without cement—a condition produced by enormous pressure, those in which the cement is lime carbonate, those in which it is iron oxide, and fourthly, the stones in which silica (quartz) forms the binding tie. There are western sandstones which illustrate the first two classes; the Connecticut sandstone fully illustrates the third, while the dense, refractory and difficult quartzitic Potsdam sandstone of northern New York illustrates the fourth.

Sandstones are easily recognized in most instances, though in very compact varieties the hand-glass, only, leads to the detection of their character. It is unnecessary in an article intended to furnish a few leading outlines of classification to discuss either limestones or sandstones further in their physical, chemical or structural aspects.

SLATES, SCHISTS, QUARTZITES.

Slates are the fissile rocks which split up into thin flakes such as are used for roofing purposes. These slates have been formed from clay deposits. They are, therefore, sedimentary rocks; but having undergone a sort of mechanical baking and compression, have been converted into these peculiar stones. (See Lessons of the Quarry.)

The schists are not so easily defined. They embrace many forms of rocks, all characterized by foliated (scaling and splitting into leaves, flakes, layers, etc.) structure. There are *mica schists, chlorite schists, talc schists, hornblende schists*, etc.

There are also, in all probability, sedimentary rocks, which, however, like the slates, have been formed from soft deposits of mineral material, and, having undergone *metamorphism*, have become these interesting rocks. Many accessory minerals occur in these rocks, and they frequently furnish collectors with valuable minerals. They are extensively represented over New England, and indeed, here on New York Island there are considerable areas of mica schist.

The quartzites are generally white or yellowish rocks, composed entirely of quartz. They grade somewhat into the schists, but are generally massive siliceous bodies, which have been formed by the deposition of silica throughout a sandstone. Potsdam sandstone is very generally a *quartzite*.

GRANITES, SYENITES, GNEISSES.

Granites are familiar rocks, though to the ordinary forms are to be added a number of less easily recognized rocks of this type.

Fundamentally granites are mineral mixtures of mica, quartz and feldspar; varieties are introduced by the coarse or fine condition of these components, by the different feldspars which may be

found in them, and by the different accessory minerals, some of which become essential elements of the granite. Mica is not always regarded as an essential member of the granite mass, but is apt to be present, and as it is present or absent, and as it is *muscovite* or *biatite* mica, the granite thus distinguished becomes a variety There are *biatite*, *muscovite*, *hornblende*, *pyroxene*, *tourmaline*, *epidote*, etc., granites.

Closely allied with the granites are the syenites, a name given by Pliny to the red crystalline rock found at Syene, Egypt, in which hornblende occurs as an essential constituent. Syenite was formerly defined as a granite without mica and having its mica replaced by hornblende. To-day it is more narrowly limited to granites without quartz, with or without hornblende.

The gneisses are laminated granites, that is, they have the constitution of granite, but the mineral elements which compose them are arranged in layers, in parallel bands, and the rock cleaves, divides up into plates. The gneisses vary in composition, but especially in texture, density and colors.

The gneisses are referred in origin to the original crust of the earth, and again to metamorphosed sediments. Their banding may in some cases represent bedding, but are generally attributed to mechanical pressure. Gneissoid structure may be found in eruptive rocks.

The granites in some cases may be changed (metamorphosed) sediments, but are generally regared as fluid, lava-like injections and protrusions which have crystallized. (See Lessons of the Quarry.)

Igneous or Eruptive Rocks.

The igneous rocks are conveniently divided into volcanic and intrusive or eruptive, viz., those which, like volcanic lavas, have been passed out of volcanic vents, craters, and those which, like the granitic bosses and the trap dikes, have been forced outward from deeply seated reservoirs of melted mineral matter (*magma*).

Very characteristic illustrations of the former are found in lavas which may be recent or ancient, and of these many *trachytes* and *andesites* are good examples.

Trachyte consists of sanidin feldspar, with hornblende, angite or black mica. Andesite is made up of soda-lime feldspar, with angite, hornblende, black mica and frequently numerous minute occurrences of other minerals.

A very common appearance of volcanic rocks is the flow structure; they also present quite contrasted texture, being both glassy and coarsely crystallized. An igneous rock, when in a fluid state,

may or may not cool quickly, according as it is exposed to rapid or slow radiation. If it cools rapidly its structure is glassy, and such glassy igneous rocks are apt to be superficial, while, if deeply seated, the heat of the mass is retained, and the mixture of varying chemical ingredients slowly separates into mineral components as hornblende, mica, feldspar, quartz, etc., and then the rock becomes crystallized.

A capital example, and one very near at hand, is the trap dikes forming the Palisades, Snake Hill, Wachung Mountains, in New Jersey. These rocks have been thrust up between beds of sandstone, and cooling slowly, are now, where uncovered, coarsely crystalline. On the other hand, the obsidian cliffs of Yellowstone Park illustrate the glassy igneous rocks which have cooled more quickly. The changing structure of such igneous rocks can be traced from the surface sometimes to considerable depths, the surface being glassy, and the deeper parts crystallized.

Besides trachyte and andesite, other igneous rocks are granite, syenite, phonolite, diorite, dolerite, etc. They have been divided up into a long series by lithologists which cannot be enumerated in a generalized description. These various kinds are recognized under the microscope in very thin sections, and furnish very beautiful objects of microscopic study.

Massive Mineral Rocks.

It has been pointed out above that the marbles and limestones are practically the mineral *calcite*, as are also the *quartzites* the mineral *quartz*. The dolomites are made up of extended areas of the mineral *dolomite*. So there are serpentine, garnet, tourmaline, epidote, hornblende, chlorite, talc, rocks, whose origin cannot be discussed here, but are recognized in the mineral which constitutes them.

Teachers will find examples of sedimentary and crystalline rocks in the sandstones, limestones, marbles, granites, slates and pavement flags of our city. Nothing can be more instructive than to pass along a street and examine the building stones of which they are made. Their varying structure, color, density, texture, components can here be closely seen.

For igneous rocks in this vicinity the trap quarries in the Palisades are serviceable; and for examples of a massive mineral rock the serpentine of Staten Island and Hoboken can be profitably visited.

The Quarry and Its Lessons.

By L. P. Gratacap, Assistant Curator American Museum of Natural History, New York City.

I.

WEST RUTLAND lies between little cottages of workmen, and almost instantly a tourist realizes he is in a marble country. Marble slabs are seen and marble sidewalks are met. Marble blocks in huge heaps, or structurally arranged like towers, form a dazzling surface around him, while incessant iron saws cleave through the marble blocks, and all around are the works of the famous marble quarries of Rutland.

Before the visitor on the side of a rounded hill yawns a wide opening whose walls descend 200 feet below him. The persistent hammering of drills indicates the slow labor of dislodging the marble. Broad arches of marble and separating walls between the pits hold up the overhanging hill. Far below, the lateral tunnels undermine the hill for a horizontal distance of 900 feet. The marble is white, crystalline, and brilliant. This limestone represents a deposit of *carbonate of lime*, in all probability organic in origin, viz.: made up of the shells and hard parts of marine animals that underwent immense compression, strain and elevation, and that as the heat developed the original beds of more or less soft, half-consolidated material we rechanged to the hard, crystallized, durable and shining marble.

What a lesson this is! Think of those distant periods when the first sediments were forming in the primeval ocean that rolled its waves where now the Green Mountains are seen; how those sediments of lime were slowly lifted, hardened, and gradually, as the earth's crust contracted upon its shrinking nucleus, the whole mass was increasingly solidified, heat and placidity developed, crystallizing forces set in, and the original amorphous soft body of calcareous mud changed to the beautiful and shining marble of these quarries. (See Dana, Geikie, Green, Prestwich.)

II.

Near the Water Gap, where the Delaware breaks through the Kittatiny range, a cut in the hills shows an open quarry of limestone, in which a few workmen are blasting out blocks to be sent to the kilns and burned into quicklime. The limestone is gray and we find it to be crowded with the impressions of shells and with entire shells as well.

These shells once covered animals in marine waters, and where this hill is now found, over a hundred miles away from the Atlantic, myriads of these small shells, with their occupants alive in them, lived, flourished, died. What a lesson this quarry teaches!

Geologists tell us that the shells belong to the middle period of the Palæozoic age; that these particular shells are not now living, although related species and genera are; that ages have passed since they became buried and that since then new groups of these shells have arisen and passed away,

These fragments of limestone teach us of the changes in life; of *evolution*—that slow progress of life constantly introducing new forms of living creatures as the old as slowly and reluctantly disappear. (See Osborn, Cope, Brookes, Hutchinson, Headley.)

III.

Near the Helderberg Mountains, at Clarksville, far south of the Catskills, are superficial quarries of flagstone, our street sidewalk stone.

Taking up a piece of the stone, one will notice its granular character, and a little knowledge will disclose that the rock at the top of this hill has been formed at the margins of water basins, that it represents a *shore mud* hardened and changed to stone. These beds are some fifty feet thick, and the original thickness must have been over ten times that depth. Where did this material come from? Exactly as to-day the rivers carry their burden of sediment to the ocean, or the little streams add accumulations to the bottoms of lakes, so when these Hamilton slates were formed the streams from surrounding areas brought their burdens of clay and fine sandy deposits to this place. The whole mass was raised and those hardening agencies—heat, compression, and mineral cement, from water penetrating the soils, laden with lime or silica—formed these useful flagstones. The same lesson is taught along the Delaware River, between Port Jervis and Great Bend. The hills abound with slate or paving-stone quarries. (See Austey, Hall, Geikie, Tyndall.)

IV.

The granite quarries at Mt. Desert enforce a different lesson from that derived from the marble, limestone and sandstone quarries. This granite, composed of quartz, feldspar and mica, is a crystalline rock whose ingredients were formed from cooling fused mineral material.

At a period almost unimaginably distant was the focus of the energies of heat. The semi-liquid body of mineral matter was here slowly cooled, and chemical affinities asserted themselves, the feldspar and mica formed, while, in cases where enough other chemical

elements occurred to bring about the formation of different compounds, other minerals were formed, and through the intervals and interstices of all the clear quartz separated out.

This singular conception is of grave importance. The granites, now forming the surface, were at one time either deeply buried under overlying masses as semi-fused bodies, and have been uncovered by the removal of these super-incumbent layers, *or else*, these granites have been forced outward to the surface from their interior basins and were pushed up to make the borders of the continent. (See Merrill, Shaler, Iddings, Van Hise.)

V.

In Pennsylvania occur extensive slate quarries. These are roofing slates, and display a variety of colors, pinks, reds, blues, grays. They are split from the blocks of slate, coming off in thin flake-like slabs or plates. This remarkable property of cleavage gives the slate its especial interest.

The slates themselves are baked clay beds, but their change from simply hardened clay has been accomplished by heat and by compression. The latter developed the slaty cleavage, for it was shown conclusively by Sorby in 1849, that this structure was due to the forcing of all flattened and linear particles into parallel planes approximately perpendicular to the pressure, and that all air-cavities and particles of moisture are flattened likewise.

The experiment has been made of compressing beeswax, clay, and other substances and it has been found that the pressure caused leaves or plates that come off similarly to the plates of roofing slates.

The slate-quarry then teaches us how, as mountain making was going forward and the wrinkling surface of the earth folded up, this slaty structure was produced, and these invaluable slates made. (See Tyndall, Sorby, Daubrée.)

So the quarries teach their thoughtful visitors lessons of differing import, according to the nature of tho rocks. The teachers and class can find in any quarry suggestive food for instruction, reflection, and imaginative entertainment.

Sound, Heat and Light.

By I. Edwin Goldwasser, Instructor, New York City.

THE specific work to be covered by this article is a practical setting forth of a series of lesson plans for the teaching of the three forms of vibratory energy, Light, Heat and Sound. It is more than probable that all teachers will not agree either in the selection of appropriate material, or experiments, or in the method of presentation. But whatever may be the difference in these particulars, there cannot be two opinions regarding the principles which must be our guides in all instruction in science. It may be that but few of my readers will agree with my selection of illustrations; many would include topics that I have omitted, or may consider essential, others which I have not mentioned. Still it seems to me that there are certain principles, almost axiomatic, which must underlie all rational science-teaching. All differences in method are traceable to a difference of opinion regarding the applications of these principles. Therefore, in order to present matter which should be universally acceptable, I purpose briefly to present an outline of those basic ideas which from a practical and pedagogic point of view, should be subsumed.

There is but one way to teach experimental sciences, and that is practically. This does not mean that the teacher is to perform the experiments while the pupils make notes. Such procedure differs only slightly from actual verbal dictation of the principles which it is necessary to impress. It is not possible, nor, in the elementary schools, is it desirable that each child shall perform for himself all the experiments that are prescribed. Bain says that the impressions made on the mind by the actual objects, as seen, are far beyond the efficiency of words or description. Still, seeing is not enough. If the pupils are not permitted to do some part of the experiments themselves, we are not affording an opportunity for the development of habits of accuracy and carefulness, of that sense of responsibility and pride in the result of one's own labor—qualities valuable not alone in themselves, but because of their indirect influence on character. The teacher should so regulate his work that at the end of the term each pupil shall have some specific work to do in at least one experiment. This, be it understood, applies to the class-room work, and is independent of that experimental work which is to be done by the pupils at home. Mere ability to do things, however, is not the aim of instruction in science. Experimentation becomes science when the results are systematically arranged and tabulated.

After the children have, from specific experiment of general observation, grasped certain effects and reasoned out their causes, when they have embodied the results of their observation and reasoning in a brief statement of the principle involved, further experiments should be resorted to, to test the validity of the conclusions reached. Here the skilful teacher will find free field for the exercise of his peculiar powers. He must draw from the whole range of the children's experience, trying, as much as possible, to get commonplace illustrations. If we can get our children to see the truth for themselves, to seize the principles that underlie the phenomena of every-day experience, we are investing their daily life with a new sanctity. The ways of Nature are humble though her ends are sublime. If we can have a real appreciation of the universality of the laws of Nature we are accomplishing a work whose importance cannot be minimized. "The laws of Nature are the thoughts of God," and the best religion is a real understanding of the magnificence and grandeur of Nature.

A final word should be said regarding the use of the text-book. *The teacher and not the book* should be the master. No texts should be assigned in advance of experiments and illustrations in the classroom. The purpose of the work is primarly educative and not instructive, and we can not educate if we first present to the children the very results which we wish them to secure by independent observation, reasoning, and generalization.

No notes should be taken by the pupils during the process of the experiment. After the questions have been answered and all the information necessary has been elicited, time may be given for writing and drawing. The blank books should be ruled so as to form four columns. The first is to be devoted to an account of what was done, the second to what was seen, the third to what was inferred, while the fourth may be reserved for drawings.

No original experiments that a teacher could devise could answer the purpose of the work so well as those given in the special text-books. Here and there a teacher should exercise his originality, but it is safer and wiser to follow precedent. I have used Gifford's Elementary Physics and Shaw's "Physics by Experiment." Thompson, Brown & Co. publish the former and Maynard, Merrill & Co. the latter.

SOUND.

Though most of the text-books treat of heat first, I have chosen sound, as it furnishes visible proof of the existence of vibrations.

Lesson 1. How sound is produced. Its nature. Vibrations. Shaw, Experiment 113. Gifford, Experiments 131, 132, 133. In

Shaw's experiment, use a lamp chimney instead of a bell jar, and omit all names and definitions. In Gifford, use a mandolin instead of a piano. Introduce the term *vibration*. A medium is necessary. Explain the term medium. Omit mention of the ear. When sound is transmitted, it is the wave of sound that travels; the particles or molecules of the medium move only a very short distance. Prove this by attaching at one side of the room one end of a long rope. Hold the other end in the hand and cause waves to travel along the rope. Speak of the waves of the occan; a piece of wood will bob up and down while the waves seem to rush toward the shore. Speak also of the waves that pass over a field of high grass, or ripening grain. Other media than air transmit sound. Experiments 134 and 135, Gifford.

Lesson 2. Velocity. Loudness. Reflection. Echoes.

The subject of velocity may be introduced with a talk on the common observation of the difference in time between seeing lightning and hearing the thunder, and others of the same type. Give the actual velocity of sound. Emphasize the fact that this figure is for transmission through air. Experiment 117, Shaw. Have the pupils perform for themselves the experiment at the foot of page 149, Shaw. Loudness does not influence the velocity. Experiment 137, Gifford. Explain *amplitude* briefly. Experiment 119, Shaw. Together with the discussion of echoes. Speaking trumpets. Speaking tubes. For voluntary home work pupils may prepare an explanation of the telephone or phonograph.

Lesson 3. Musical sounds. Pitch. The Voice. The Scale. The Ear. For distinction between music and noise see Shaw, page 156. For pitch. Experiments 138, 139, 140, 141, 142, Gifford. Speak briefly of the scale and ask questions regarding the tension of the vocal chords when the various tones are sung. Have the class sing the scale. Experiment 136, Shaw. Omit all technical terms and explanations. Make brief reference to the sounding boards of concert stands, theatres, musical instruments. The murmur of a shell and what causes it.

The ear, its construction and action in review of previous work in physiology. Speak of the wonderful physical condition of the tympanum while listening to a full orchestra. At this point the explanations of the telephone and phonograph may be given.

Heat.

Lesson 1. Heat is known only by its effects. Sources of heat. Effects of heat. Expansion. Temperature. The thermometer. Experiments 76, 77, 78, Gifford. Experiment 79, omit question 3. Experiment 80, color of water. Experiment 81, emphasize that

temperature is only a measure of heat. For explanation of the thermometer, see Shaw, pages 116 to 119, inclusive.

Lesson 2. Changes in the state of matter as effects of heat. Gifford, Experiments 83, 84, 85, 86, 87, 88; add here the effect of perspiration in cooling the body, 89. The steam engine may here be described very briefly, and details may be worked up by pupils.

Lesson 3. Transfer of heat. Radiation. Conduction. Convection. Experiments 91, 92, 93, Gifford. Experiments 94, 95, 96, 97, Gifford.

Lesson 4. Experiments 99, 100, Gifford.

Lesson 5. Experiments 101, 102, 103.

Lesson 6. Review and completion of work.

Light.

Lesson 1. Sources of light. Shadows. Application. Page 126, Gifford; page 172, Shaw. Experiment 139, Shaw; omit representation of rays of light, or touch very lightly. Experiment 140 and 141, Shaw. Eclipses of the sun and moon. Page 132, Gifford.

Lesson 2. Nature of light. Velocity of light. Reflection. Refer to the vibratory nature of light. For velocity, see Gifford, pages 132 and 133. Experiments 145 and 146, Shaw.

Lesson 3. Refraction. Lenses. Experiment 170, Gifford, and mention the results of Experiment 169, also in Gifford. This is contrary to principle, but it is a question whether the law to be derived is not of sufficient importance to warrant us in doing as suggested. Take only three or even two kinds of lenses. I would suggest that only the double convex and the double concave lenses be taken up. I should simply say that the former gather rays and the latter scatter them, and would then show this by any simple method. Further than this, it would be useless to go.

Lesson 4. Color. Illustrations. Experiment 179, Gifford; omit the topical outline. Call attention to the order of the colors and refer briefly to the fact that the red are the heat or thermic rays, while the blue are the actinic, and explain what is meant by these terms. Explain the phenomenon of the rainbow. I should not refer to the color of objects nor should I give any explanation of the eye or of the principles of vision.

Lesson 5. As many of the practical questions that are given on pages 143, 144, Gifford, as have been covered by the work.

Simple Machines.

By Oswald Schlockow, Instructor, New York City.

THE method here indicated presents concretely the educative material; thus, the pupil exercises his powers of observation, and by graded steps he infers the general truth involved in the phenomena, and expresses this in his own words. Well directed questioning, then, applies the principle inferred to related particulars.

No text-book is needed by the pupil, the note-book embodying his own efforts will suffice. Encourage pupils to verify the results of their discoveries by consulting reference books to secure additional details.

As the aim of this article is to present a mode of procedure, and not to present scientific truths as such, two or three simple machines will illustrate the method, leaving those who desire to originate experiments underlying the other simple machines.

The wedge alone does not readily lend itself to this method of treatment.

Method.

The teacher, in the presence of the class, performs, or requires each pupil to perform, the experiment.

The pupils are then required to state the observation, as well as the inference, in their own words. The results of these three operations are then written by the pupils, inspected by the teacher, and are then transcribed in note-books. Illustrations will fix the results and secure an intelligent comprehension of the experiment.

Experiment.

1. (*a*) Place a pencil upon a book so that the end will project about 1½ inches. Place another book upon the projecting end and press upon the free end.

Lever—Observation: A certain amount of power is required to lift the book.

Teach terms, weight, power, fulcrum. 1. (*b*) Decrease the distance between fulcrum and weight.

Less power required to lift the book.

Inference: The smaller the distance between weight and fulcrum the less the power required to raise weight.

1. (*c*) Increase the distance between fulcrum and weight.

More power required to raise book.

Inference: The greater the distance between weight and fulcrum, the greater the force required to lift weight.

Secure four small rings of equal weight.

2. Experiment: Balance a stick; place one ring at any distance from the fulcrum; slide another ring along the other side until the first ring is balanced.

Observation: The distances from fulcrum to rings are equal.

Inference: When power is equal to weight, they must be at equal distances from the fulcrum.

3. Place two rings at any distance; slide a ring along the other side until it balances the two rings.

The distance from fulcrum to single ring is twice that from fulcrum to the two rings.

Inference: When the weight is twice the power, the distance from power to fulcrum is twice that from the weight to the fulcrum.

Adequate variations and correlation should be given for drill.

Let the pupils infer or determine by experiment what would be the result if the power is equal to ⅓ of the weight, etc. Have this law expressed in the form of a proportion:

The distance from the fulcrum to the power is to the distance from the fulcrum to the weight as the weight is to the power.

Now correlate with arithmetic:

1. What force, applied 40 inches from the fulcrum, is required to lift a weight of 200 pounds, placed 2 inches from the fulcrum?

2. How far from the fulcrum must a force of 16 pounds be applied to lift a weight of 350 pounds, placed 3 inches from the fulcrum?

3. The length of a lever is 40 inches. Where must the fulcrum be placed so that a force of 8 pounds may lift a weight of 100 pounds?

Application: Let the pupil mention some well-known objects: namely, a lever, the crowbar, a pair of scissors, nut crackers, muscles and bones, sugar-tongs, etc., etc. Deduce the relative positions of the fulcrum, weight, and power. This gives rise to three classes. Use mnemonics to fix these in memory.

Power (F)ulcrum Weight
(F)irst

Power (W)eight Fulcrum
T(W)o

Fulcrum Weight
(P)

PULLEY.

4. Pass a cord over a pulley; attach a weight of 10 lbs., and fasten a spring balance to the free end; then pull and raise the weight.

The balance indicates a force of 10 lbs.

When one pulley is used, the weight is equal to the force required to lift it.

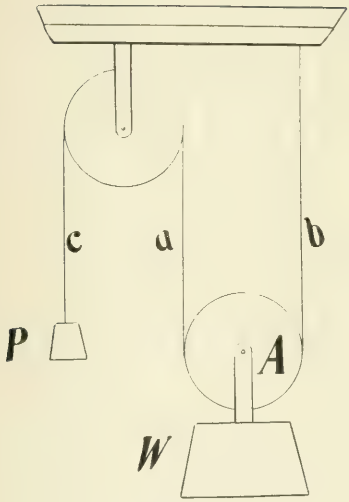


DIAGRAM 1.

5. (*a*) Use one fixed and one movable pulley, as per Diagram 1. Attach a weight of 10 lbs. to the movable pulley, and fasten a spring balance to the free end of the cord.

The balance indicates a force of 5 lbs.

With one movable pulley the power is equal one-half the weight.

Explain the term movable pulley.

Explain that since there is a pressure of 10 lbs. on the movable pulley A, each string, "a" and "b," will support 5 lbs.; a force of 5 lbs. only will consequently be required at "c" to lift the weight.

5. (*b*) Experiment: Raise the weight 6 inches. Note how far out the free end of the cord must be pulled.

Observation: The free end is pulled 12 inches.

Inference: When the power is equal to one-half the weight, the distance over which this power acts is twice as great as the distance through which the weight is raised; or 10 lbs. over 6 inches equals 5 lbs. over 12 inches.

6. Construct an apparatus of pulleys, two movable and one fixed.

A force of 2½ pounds is required to raise the weight.

When two movable pulleys are used the power equals ¼ weight.

Explain the reason for this by diagrammatic analysis, as indicated at the end of Experiment 5 (a).

Repeat experiment to determine relation between distances over which the power and weight act, as in Experiment 5 (b).

The general law may be somewhat too difficult to be expressed mathematically by the pupil. Assist by presenting the results as follows:

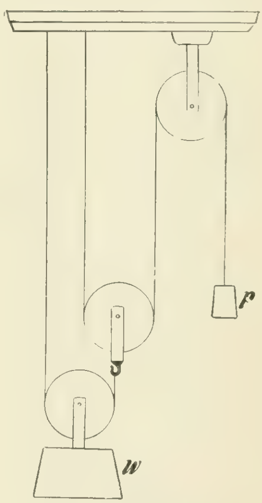


DIAGRAM 2.

When 1 movable pulley is used, power = 1-2 weight = 1-$(2)^1$
When 2 movable pulleys are used, power = 1-4 weight = 1-$(2)^2$
When 3 movable pulleys are used, power = 1-8 weight = 1-$(2)^3$
When 4 movable pulleys are used, power = 1-16 weight = 1-$(2)^4$

Therefore with x number of pulleys power 1-(2)x.

Application: Let pupil explain under what conditions he has seen pulleys used. Observe that an arrangement as indicated in diagram is awkward and consumes much time to rig up. Show how the block and tackle overcomes these disadvantages without any loss of power.

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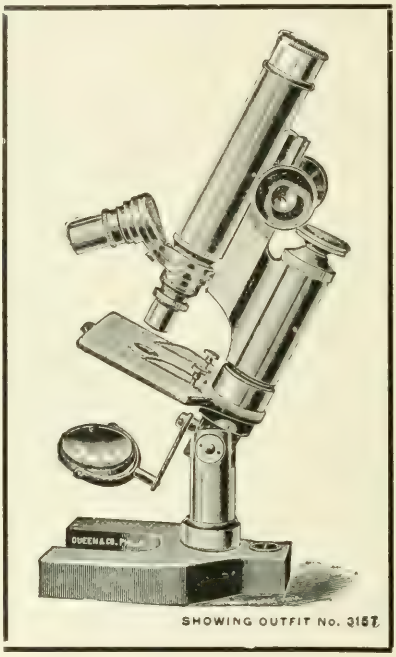

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